

THE CURRENT STATE AND FUTURE PROSPECTS OF THE U.S. PHOTOVOLTAICS INDUSTRY

HEARINGS BEFORE THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES NINETY-EIGHTH CONGRESS SECOND SESSION

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CONTENTS

WITNESSES

September 11, 1984:

Page

PANEL 1

Paul Maycock, president, Photovoltaic Energy Systems, Inc., Alexandria, VA	2
Roger G. Little, president, Spire Corp., Bedford, MA.....	19
John Day III, president, Strategies Unlimited, Mountain View, CA.....	29

PANEL 2

James H. Caldwell, Jr., president, ARCO Solar, Inc., Woodland Hills, CA ..	56
John Corsi, president, Solarex Corp., Rockville, MD.....	67
Ernest Lampert, president, United Energy Corp., Foster City, CA.....	80

PANEL 3

Zoltan Kiss, president, Chronar Corp., Princeton, NJ	93
John Sanders, president, Intersol Power Corp., Lakewood, CO	105
September 19, 1984:	
Hon. Nicholas Mavroules, a U.S. Representative from the State of Massachusetts.....	123
Hon. Ron Wyden, a U.S. Representative from the State of Oregon.....	137
Sam Enfield, Export Council for Renewable Energy, Washington, DC.....	142
Clyde Ragsdale, Solavolt International, Phoenix, AZ	167
Scott Sklar, director of programs, Solar Energy Industries Association, Washington, DC	180
William Sharkey, Director, Energy and Transportation Policy, U.S. Department of Defense.....	191
James R. Phillips, Deputy Assistant Secretary for Capital Goods and International Construction, U.S. Department of Commerce.....	317

(III)

THE CURRENT STATE AND FUTURE PROSPECTS OF THE U.S. PHOTOVOLTAICS INDUSTRY

TUESDAY, SEPTEMBER 11, 1984

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Dave McCurdy presiding.

Mr. McCURDY. Why don't we have the first panel come on up to the panel if they're here. Mr. Day, I've met; Mr. Maycock and Mr. Little.

Good morning.

I'm Dave McCurdy, a member of the subcommittee from Oklahoma. I will be chairing it today. It gives me great pleasure to welcome our witnesses and guests to our first day of hearings on the current state and future prospects of the U.S. photovoltaic industry.

Chairman Fuqua regrets that he cannot attend this important hearing but committee business abroad has detained him until tomorrow.

Photovoltaics is a marvelous technology. It takes sunlight and converts it to useful electricity with no moving parts. It is something like a magic box. Unfortunately, that magic box is quite expensive. Even the cheapest of today's photovoltaics systems produces electricity at a cost of about 10 times the current price of conventional alternatives.

The good news is that there are many remote applications, such as water pumping, refrigeration and village power in the Third World, or marker buoys, highway signs and cathodic protection of pipelines at home that are cost-effective even at those high prices. The better news is that the cost of photovoltaic electricity has been falling rapidly by a factor of 15 in the last 10 years, with further reductions certain to come.

In many ways, photovoltaics is the brightest and most dynamic of the new energy technologies. Cell efficiencies have improved from a range of 1 to 8 percent in 1975 to a range of 10 to 24 percent today. Module lifetimes have been extended from an expected 1 to 5 years in 1975 to more than 15 years today.

Module costs have been reduced from \$3,000 per square meter to less than \$500 per square meter. U.S. industry sales have grown from a few hundred kilowatts a year to 15 megawatts in 1983.

Today, there are at least three technologies which appear capable of meeting the cost goal of 6.5-cents-per-kilowatt hour set by the Department of Energy last year. These are silicon ribbon, amorphous silicon and concentrating systems using high-efficiency cells. Both the Department of Energy and the industry have aggressive programs in all three of these technologies.

However, underneath the surface, certain disturbing signs are appearing. In the past year, a half dozen firms have dropped out of the photovoltaics business. Two of the industry leaders with us today have undergone significant layoffs in the past 3 months.

None of the U.S. industry teams has seen fit to invest in the kind of large-scale automated production lines which could bring the cost of today's technology down by a factor of two and open up a whole new set of markets.

The failure of Congress to extend the renewable energy tax credits beyond their expiration date of December 1985 has cast a long shadow over the future of the industry, and with deficit reduction likely to be the primary order of business for the next year, renewal of the tax credits will be at best an uphill struggle.

The goal of our hearing today is to look at the industry and the incentives which are in place today and determine what works and why and how we can best work together to ensure that the U.S. retains its dominant position in this important high-technology field.

Without objection, permission will be granted to take photographs and make recordings of the proceedings today. I understand that we will have one of our colleagues, Ms. Schneider, appearing shortly and at that time, we offer her an opportunity to make a statement if she desires.

The—let me get my new list here—the witness list this morning—the first panel will have an industry overview. Mr. Paul Maycock, president of PV Energy Systems, Inc., 2401 Childs Land, Alexandria, VA; Dr. Roger Little, president of Spire Corp., Bedford, MA; and John Day, president, Strategies Unlimited, in Mountain View, CA.

Gentlemen, welcome. If you have—we have copies of your statements. They can be submitted for the record with no objection and they will be made part of the record.

We would like for you, at best, to perhaps summarize as quickly as possible your statements and give us, I think, the main points, the key points that you'd like to convey this morning and then we'll have questions at that time.

STATEMENT OF PAUL D. MAYCOCK, PRESIDENT, PHOTOVOLTAIC ENERGY SYSTEMS, INC., ALEXANDRIA, VA

Mr. MAYCOCK. Yes, Mr. Chairman.

Mr. Chairman, today I'd like to share the results of some recent analysis of the photovoltaic industry. I'd like to start with roughly where we're at, see if we can determine where we might go and then see what options are possible for the committee.

I've just completed an exhaustive study of the photovoltaic market from now to 1995 considering with and without the tax credit extension and expansion. The primary conclusion of this

study is that the U.S. photovoltaic industry will lose their dominant world position to the Japanese producers by as early as 1990—as early as 1990—and the world PV module market will only grow from its present level of approximately 30 megawatts in 1984 to 140 megawatts available to the U.S. industry in 1990, with an additional 40 megawatts captive to the Japanese producers.

The module prices which are presently in the \$6 to \$7 range factory prices will drop to approximately \$4.50 to \$5 per watt by 1990 and we will lose our price leadership and we will lose our market share. However, if the tax credits are extended or equivalent options are enacted by the Congress and implemented by the Department of Energy, the U.S. producers can continue to have the largest share of the world PV market and the market will continue its explosive growth to approximately 500 megawatts in 1990 world-wide.

Now, I add that when I say 500 megawatts, it includes the consumer-equivalent product, that is, calculators and watches are converted into their power output, and it includes concentrators at their full output value. So if you see some other numbers, you need to be sure that you ask the assumptions on these two issues.

With profitable prices in 1990, and I mean profitable prices, as low as \$3 per watt, nearly 2,000 megawatts, which I parenthetically add is only roughly one nuclear reactor's worth of power, will be sold in 1995 with prices at as low as \$2 per watt. The U.S. manufacturers can maintain their market share leadership through 1995 provided the tax credits are extended.

Let me digress for a moment to review 1983 and 1984. In the text, I've given the detailed shipments by company and by product for 1983, totaling approximately 13 megawatts. Arco Solar is the world leader, with United Energy Corp. a close second and Solarex the third producer in the U.S. market.

It can be seen that the dominant three companies in the United States are each developing a unique approach to photovoltaic modules, which I think is very exciting from a technology point of view. Arco Solar, the world leader, and clearly delivers more product than that of Japan and Europe combined, sells single crystal silicon modules.

United Energy Corp. is delivering concentrators, using Fresnel lens and single crystal silicon solar cells. Solarex predominantly sells cast semicrystalline modules.

If we review the major events in 1983, we can see, despite some gloomy forecasts, some major successes, but we need to look very carefully at where the successes came from. In 1983, the market nearly doubled over 1982. 1984, there appears to be some slowing with the world market only increasing by about 30 percent.

Virtually all of the growth from 1982 to 1984 in the world market is due to the tax credit-stimulated sales in California, the amazing Arco Solar 6-megawatt plant, the roughly 5 megawatts that United Energy has put in place, and other tax credit-stimulated sales.

The impact of the tax credit is not just volume. We would not have a 5-megawatt, fully automated, stand alone operating system in the upper desert of California unless we had the tax credits. The

private sector would probably not have purchased such a large photovoltaic facility without Federal assistance prior to 1990, 1995.

In addition to the tax credit-stimulated activity, the Department of Energy has emphasized its resources on the amorphous silicon option, which indeed, on paper and in theory, is probably the most exciting option available to photovoltaics.

Simultaneous with the award of approximately \$4 to \$5 million worth of DOE funds for four major contracts, the industry has announced the intention to produce six major plants: Chronar Corp., which we'll hear from later, is building plants in its home base, Trenton, NJ, Port Jervis, NY, and in Wales, and has intentions to build plants and options to build plants in four other sites.

Energy Conversion Devices, in cooperation with Sohio, is building a plant in Troy, MI and in Ohio and other plants are in the research stage.

Solorex is in production as a result of their acquisition and license of the RCA technology in Newtown, PA.

So that the amorphous silicon option is not just a research option; people are allocating capital resources. The option is risky because at the moment, the hope of amorphous silicon is reasonable efficiency and reasonable cost and that yet remains to be seen.

Spire Corp., which we're going to hear from in a moment, has successfully sold photovoltaic manufacturing equipment throughout the world.

The Georgetown University facility, which was recently completed and will be dedicated on October 4, is an astounding statement of what photovoltaics can do on an in-town roof, 300 kilowatts in the middle of a university campus on the roof.

Now, as we look forward—1990 is probably the easiest year to talk about because of the uncertainty and the rapid change in the industry, and in my text, I have given you a forecast of all of the consumer market applications areas until 1990 and I won't dwell on it.

My best estimate is the highest market that we can see in 1990 for the photovoltaic industry is approximately 90 to 100 megawatts in the United States, unless the tax credits are extended and we could stimulate an additional 200 to 300 megawatts of sales. This additional 200 to 300 megawatts is absolutely vital in the sense that it will pull in the 50-megawatt plants which can demonstrate the ability of ribbon; can demonstrate the ability of amorphous silicon; can demonstrate the ability of concentrators to increase the performance and reduce the cost.

The last statement that I would like to present goes to the end of my text, which is where I try to consider what options are before the committee. This committee has been absolutely instrumental in leading the photovoltaic industry in terms of Federal role. The committee helped establish the Photovoltaic R&D Act of 1979; the committee has regularly marked up the DOE budget; has made the SMUD project in Sacramento, CA, a reality; and has been the leader in photovoltaic initiatives.

The initiatives that I feel the committee should at least consider are summarized in the following four ways: The first option is one of let the industry alone, and the question is, will the \$80 million that the industry is presently investing in photovoltaic cost reduc-

tion and probably an additional \$60 to \$80 million of losses, will this \$140 million capital investment by the industry be sufficient to pull in a viable industry? It's very difficult to answer that question, but one option would be for the Government to leave the industry alone and let them do their thing. This is essentially the present administration's option—is to provide research for research sake, work on the very high-risk areas and assist the industry, if possible, through tax credits and international assistance.

The other options that I think the committee should consider is to be absolutely sure that the full 100 megawatts at the Sacramento Municipal Utility District is built. This is going to be very difficult because it's a multiyear program and we deal in annual budgets, and the SMUD requirement for phase III is significantly larger than it was for phase II and will be significantly larger for phase IV. It would be interesting to see if we couldn't get a multiyear authorization for the SMUD project.

In addition to the SMUD project, I feel that we need another 100 megawatts of market assistance that should be centered about—around the three regional experiment stations. They are presently called residential experiment stations: One in New England; one in the Southwest; and one in Florida.

I think that 100 megawatts' worth of small distributed systems should also be assisted into existence. Now, by assistance, I mean costsharing by the Government of the gap between full economic viability and the best price that you can get from a competed fixed-price bid.

The third option is in availability of the Mavroules bill, which is the legislation of the land and the law of the land, and I understand you are going to hear from Congressman Mavroules in your next session. The Mavroules bill, as we all know, says that if photovoltaics is lifecycle cost effective, then we should use it in the Department of Defense. There have been recent analyses by the Jet Propulsion Laboratory that shows that several megawatts worth of opportunity can exist today and that as the prices go down, the amount of opportunity increases dramatically.

I think we should make the Mavroules bill happen.

The next option is one that I've been working personally on and that is to take advantage of the synfuels allocations of funds, and as you well know, there are two schools of thought: One is to give all of the synfuels' \$13 billion back to the Treasury; ranging to only give partial amount of that back. The compromise that we are trying to work on is to redirect about 2 billion dollars' worth of the synfuels appropriation into the renewal energy area. Hopefully, photovoltaics would deserve at least a billion of that two.

The last option that I wish to discuss is going to be addressed, I believe, by Mr. Little, and that is to assist in bringing in the new manufacturing technology. The Jet Propulsion Laboratory, in its management of the technology transfer and technology development part of the photovoltaics division, had ready to go in 1980 a set of contracts which would cause the high-technology options, the high-risk options, to be on the manufacturing floor in 2 to 3 years. Those contracts were all terminated and the funds were not appropriated.

I think that a multicompeted award of manufacturing methods for the high technology could be an assistance. It does have some downside if you're already well established in the business because it means that the Government is assisting in setting up competition. I do believe that the best and most effective option is still the extension of the tax credits and if there is anything this committee could do to assist that, it would be very helpful.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Maycock follows:]

TESTIMONY ON
"CURRENT STATUS AND FUTURE PROSPECTS
OF THE U.S. PHOTOVOLTAIC INDUSTRY"

by

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U.S. House of Representatives
Committee on Science and Technology
September 11, 1984
Room 2318 Rayburn Building
Washington, D.C.

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Mr. Chairman, Members of the Committee:

Today I would like to share the results of my recent analysis of the future of the U.S. Photovoltaic industry. Two cases were considered. First, we forecast the future PV prices, world PV module market and U.S. market share assuming that the tax credits were expanded to 25% and extended to 1989. Alternatively, we forecast the PV prices, world PV market and U.S. market share assuming the tax credits are not extended beyond 1985. The results of this analysis have just been published by my company in a report entitled, "PHOTOVOLTAIC TECHNOLOGY, PERFORMANCE, COST AND MARKET FORECAST TO 1995: A STRATEGIC TECHNOLOGY AND MARKET ANALYSIS": September 1, 1984.

The primary conclusion of the study is that the U.S. Photovoltaic industry will lose their dominant (60%) world market share to the Japanese producers by 1990 and the world PV module market will grow by 1990 to only 180 megawatts (MW) with module prices at \$4.50 per Watt peak (1984\$), if the U.S. tax credits expire in 1985.

However, with the tax credits extended, the U.S. producers will continue to have the largest share of the world PV market and the market will continue its explosive growth to 500 MW in 1990 with profitable module prices at \$3/Wp. Nearly 2,000 megawatts will be sold in 1995 with prices at \$2/Wp. The U.S. manufacturers can maintain their market share leadership through 1995, provided the tax credits are extended.

The Status of the Private PV Industry in the U.S.

Before I cover the details of the study, the current status of the U.S. PV industry will be discussed.

U.S. PV Production: 1983

Module shipments by principal U.S. manufacturers in 1983 are estimated to be as follows:*

	1983 Shipments (MW)	Cell Type	Comment
ARCO Solar	6.0	Single Crystal	
United Energy	4.5	Concentrator	
Solarex	1.5	SEMIX	
Solar Power	.4	Single Crystal	Shut down in '84
Photowatt	.3	Single Crystal	Sold out Dec. '83
Solec International	.3	Single Crystal	
Mobil Solar	.1	Ribbon	
Motorola	.1	Single Crystal	
Intersol	.02	Concentrator	
TOTAL	13.2 MW		

* PV NEWS, Vol 3, No. 2, Feb. '84.

-2-

It can be seen that the dominant three companies in the U.S. are each developing a unique approach to PV modules. ARCO Solar sells single crystal silicon modules. United Energy Corporation is delivering 100X Fresnel lens concentrator modules. Solarex sells cast semicrystalline modules. Exxon's Solar Power Corporation has been sold by Exxon. Solar Power, which developed single crystal solar cells recently stopped production. Other manufacturers, such as Solec, Solenergy and Sollos, are developing single crystal modules but have significantly less technology development and research in their companies. Mobil Solar Corporation is developing edge-defined film growth ribbon. Several other U.S. companies are ready to enter the PV market through amorphous silicon. These companies include ARCO Solar, ECD/SOHIO, Chronar, 3M Corporation and Spire.

In the concentrator area, United Energy Corporation shipped another 5 MW in 1984. E-Systems was reassembled under the name Entech. They shipped about 40kW in 1983 and are working hard to put together a third-party-financed project. Martin Marietta, which delivered 300kW to Saudi Arabia in 1981 and 200kW to the Phoenix Airport in 1983, has terminated all PV activities. Intersol, which shipped 20kW in 1983, has the world's most efficient module (15%), a 1MW pilot plant and several 1MW projects under negotiation.

U.S. Consumption: 1983

Of the 13.2 MW produced in 1983, the U.S. consumption of PV systems was 10.6MW. The rest was exported. A breakout of the U.S. consumption is shown in the following table.

Sector	Amount (MW)	System Installed Price
Central power sold by ARCO Solar to Atlantic Richfield	5.0	Not public: \$12/Watt cost indicated
3rd-Party-Financed Concentrators (for heat/PV hybrid)	4.0	\$20/Watt
Off-the-Grid Houses	.5	\$15/Watt
Off-the-Grid Industrial/Commercial (pumps, farms, cathodic protection)	.6	\$20/Watt
U.S. Government Projects (Georgetown, DOD)	.5	\$20/Watt
TOTAL	10.6 MW	\$15.60/Watt average

Despite the 1983 PV module sales growth of over 100% from 1982, there have been some serious setbacks for the infant U.S. PV industry. These include:

- Withdrawal from the PV business by Photon Power, Photowatt, Solar Power Corporation (Exxon) and Martin Marietta.
- 140 person layoff at ARCO Solar in June, 1984.
- 70 person layoff at Solarex in August, 1984.
- Cancellation of ARCO Solar's 10 MW plant at San Luis Obispo.
- Delay in Solarex 1 MW plant.
- Losses estimated to be over \$50 million on products sold in 1983 with an additional \$80 million spent for privately funded research and engineering.
- Continued price pressure by German and Japanese module producers.
- Entrance of Japanese power conditioning (Toshiba) and PV modules (Kyocera) into the U.S. market at competitive prices.
- Uncertainty concerning full funding of SMUD and DOE budget.
- Failure to extend the tax credits.

The major successes in 1983/84 include:

- Continued growth in the tax credit-stimulated PV sales.
- The award by DOE of four \$3-4 million contracts in amorphous silicon.
- The announcement of 6 amorphous silicon plants with 1 MW capacity and the intention of others to fund plants in 1985. The firm intentions include:
 - Chronar's plants in Trenton, NJ; Port Jervis, NY; Tennessee and Wales.
 - ECD/SOHIO plants in Troy, MI and Ohio
 - Solarex production in Newtown, PA.
- The successful sale by Spire Corporation of PV manufacturing equipment in the U.S. and abroad.
- The completion of the 6 MW ARCO Solar plant at San Luis Obispo and the SMUD 1 MW plant at Sacramento.
- The 5 MW of concentrator PV installed by United Energy Corporation.
- The completion of the Georgetown University 300kW plant using Solarex modules.

It is difficult to forecast the future of this infant industry buffeted by erratic government policy, intense foreign competition and difficult cost reduction targets. In the next section, we will forecast the U.S. market to 1990.

The U.S. PV Market to 1990

A 1990 U.S. PV market of approximately 100 MW annual sales rate, out of a projected world market of 180 MW per year at that time is a conservative, believable forecast of the U.S. market. If the tax credits are extended, the U.S. market could be as high as 300 MW per year in 1990, assuring a very exciting and dramatic arena for PV in the United States. Our present projection, with and without the tax credits, is summarized in the following table.

-4-

U.S. MODULE MARKET: MWP PURCHASED

	1982	1983	1985*	1987*	1990*
Consumer PV: Consumer Electronics, Battery Chargers to 5W (mostly from Japan)	1.0	2.0	5.0	20.0	30.0
Off-the-Grid Residential (0.2 to 2kW)	0.3	0.5	3.0	7.0	20.0
(Tax credits terminate after 1985)				4.0	8.0)
Grid-Connected Residential (2 to 5kW)	0.05	0.1	0.2	0.5	3.0
(Tax Credits Terminate after 1985)				0.3	1.0)
Communications: signals, navigational aids, microwave repeaters, telemetry	0.5	0.5	0.8	3.0	8.0
(Tax Credits Terminate after 1985)				2.0	4.0)
Diesel Hybrid/Replacement: Irrigation, water purification, cathodic protection	0.1	0.4	0.6	4.0	15.0
(Tax Credits Terminate after 1985)				1.5	3.0)
Central Station and Third Party-Financed Projects	2.0	10.0	10.0	20.0	240.0
(Tax Credits Terminate after 1985)				15.0	50.0)
Government: DOD, DOE	1.0	0.5	1.0	2.0	0.0
TOTAL MW	4.95	14.0	20.6	56.5	316.0
(Tax Credits Terminate after 1985)				44.8	96.0)

* Estimated by PV Energy Systems, Inc., 1984.

Tax Credits and Their Impact on the Photovoltaic Market Worldwide

The growth of the photovoltaic market worldwide has already slowed down considerably from prior estimates of 50 to 60% annual growth. The reason for the slower annual growth of 30-35% in the commercial market is two-fold: First, the decline in oil prices from their historic high in 1980. The oil prices may continue to decline in the short term and continue their rise of only 3% in the late 1980's. This has obviously impacted the PV market growth which was solely dependent on price reduction in modules and systems. The price reduction in PV modules has continued at 10 to 15% annually, as we foresee that this trend will continue.

-5-

Second, the economic recession worldwide put off implementing photovoltaics by at least 2 to 5 years. The balance of payment problems, poor economic climates of the developing countries, coupled with funding reductions from international financial institutions, has further impacted growth of photovoltaics overseas.

The third party-financed utility projects in 1982 and 1983 have been largely responsible for providing a special market for PV. The additional volume provided impetus for cost reductions in the last two years. We have already seen project cancellation or slow-down in the third party-financed projects due to impending expiration of the tax credits in 1985.

We see a major impact on the viability of the U.S. industry if the tax credits are allowed to expire.

- If the tax credits expire in 1985, the price leadership will go to Japanese manufacturers who are aggressively continuing the development of amorphous silicon for terrestrial use.
- PV technology development in Japan coupled with aggressive marketing by Japanese manufacturers worldwide will increase their market share from 20% in 1983 to approximately 60% in 1995 under the scenario of tax credit expiration in 1985.
- The market share leadership will change in the late 1980's from U.S.A. to Japan.
- The market leadership of Japanese will also imply their penetration of the Third World market through technology transfer and joint venture agreements in Asia, Africa and the Middle East. These markets will then be permanently closed to U.S. manufacturers.
- We expect the market share of manufacturers in the developing nations to increase dramatically in the 1990's due to enormous domestic markets that will be served through local manufacturing operations.
- The worldwide market will grow at 35% annually to only 180 MW by 1990 with modules at \$4.50/Watt (including 40 MW of Japanese grid-connected PV-powered houses).

If the tax credits are extended to 1990 and enhanced in some areas, we see some significant bolstering of U.S. manufacturing base:

- U.S. will continue to be price leader in the world over the next decade.
- Tax credits will fuel residential PV market along with third party-financed utility and commercial projects. Significant domestic demand will increase production, reduce prices and cause aggressive development of amorphous technology.
- We expect U.S. to continue to maintain its market share worldwide to 60% through 1980's and dropping to 45-50% range in the 1990's. Japanese manufacturers will continue to gain market share at a slower rate and reach 30-35% by 1995.
- U.S. price leadership will enable U.S. manufacturers to expand their presence worldwide through technology transfer and joint venture agreements. U.S. can then share the benefits through royalties and profit sharing from overseas manufacturing operations.
- Once the breakeven points are attained for grid-connected residential and central station markets, the growth in PV will occur very rapidly beyond 1990's. In the process, the largest market segment of diesel/hybrid replacement market will also become economically viable, further fueling the growth of the PV industry.
- With tax credit extension, the market will grow at 60% annual rate to 500 MW at \$3/Wp by 1990.

The detailed results of our analysis and forecast for the world PV markets for the two cases are summarized in Tables I, II and III. We show all key market sectors and the impact of the tax credits. Figure One graphically shows the results of the analysis.

TABLE I
SUMMARY OF WORLD MARKET FORECAST

Case I: U.S. Tax Credits Extended (Mwp Shipped World)			
Market Sector	1984	1990	1995
World Consumer Products	5	50	75
U.S. Off-the-Grid Residential	2	20	50
World Off-the-Grid Rural	0.2	5	30
Worldwide Communications	5	40	150
Worldwide PV/Diesel	2	100	1125
U.S. Grid-Connected Residential	0.1	3	20
U.S. Central Stations & Third Party-Financed Projects	10	240	350
TOTAL (MW)	24.3	458	1900
Japanese Grid-Connected	--	40	100
TOTAL (MW)	~ 25	~ 500	2000
PRICE (\$/Wp)	7	3	2
TOTAL (\$M)	175	1500	4000

TABLE II
SUMMARY OF WORLD MARKET FORECAST

Case II: U.S. Tax Credits Terminate After 1985 (Mwp Shipped World)			
Market Sector	1984	1990	1995
World Consumer Products	5	50	75
U.S. Off-the-Grid Residential	2	8	20
World Off-the-Grid Rural	0.2	1	5
Worldwide Communications	5	20	40
Worldwide PV/Diesel	2	10	100
U.S. Grid-Connected Residential	0.1	1	3
U.S. Central Stations & Third Party-Financed Projects	20	50	50
TOTAL (MW)	24.3	140	293
Japanese Grid-Connected	--	40	100
TOTAL (MW)	~ 25	180	400
PRICE (\$/Wp)	7	4.50	3
TOTAL (\$M)	175	810	1200

TABLE III

WORLDWIDE MODULE SALES

(Factory Prices - 1984 \$)

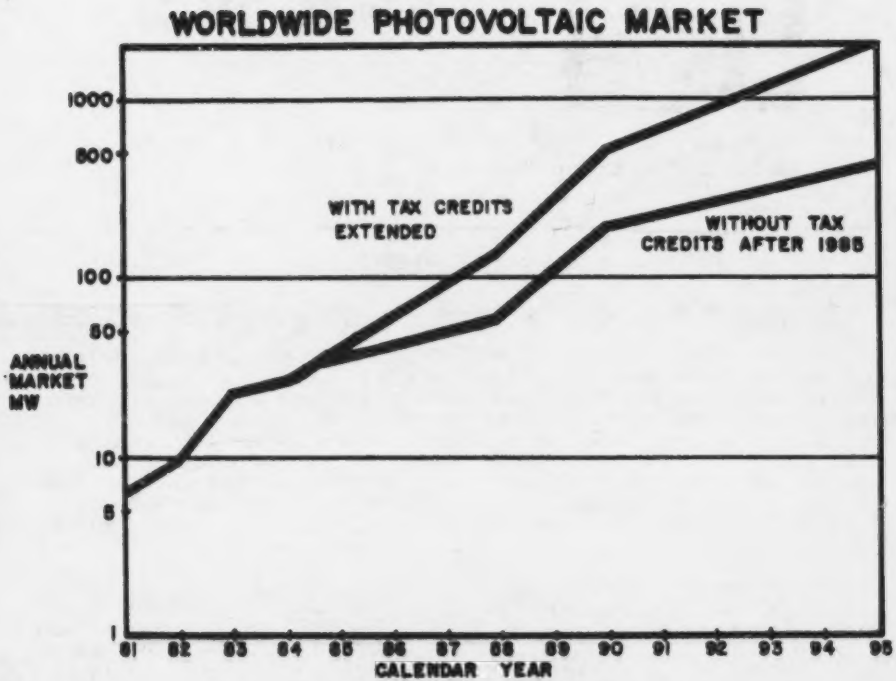
	1983	1984	1985	1986	1988	1990	1995
MWp	22	25	35	60(1)	125	500 *	2000 *
				45(2)	60	180 *	400 *
S/Wp	8	7	6	5(1)	4	3	2
				6(2)	5	4.50	3
\$/M)	176	175	210	300(1)	500	1500	4000
				270(2)	300	810	1200

(1) U.S. Tax Credits Extended to 1989

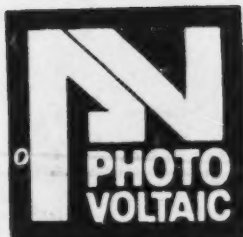
(2) U.S. Tax Credits Expire after 1988

* Includes 40MW in 1990 and 100MW in 1995
of Japanese Grid-Connected PV Powered Homes

FIGURE ONE



What can we do to assure a viable PV industry? In my newsletter, PV NEWS, for August, 1984, I proposed several options for consideration by the PV industry/government partnership. We include the editorial in its entirety on the next page.



News

ISSN 0739 - 4829

EDITOR: Paul D. Maycock
ASSOC. EDITOR: Edward N. Stirewalt

August, 1984
Vol. 3, No. 8

"BOOMER'S CORNER"

A TIME FOR BOLD INITIATIVES - OR - WE BETTER GET OUR ACT TOGETHER

Our readers probably noticed that last month Boomer did not comment on the failure to extend the tax credits. I decided to "cool off" for a month, talk to my industry friends, some PV'ers at the Department of Energy and several colleagues on Capitol Hill. Despite the angry rhetoric of the Solar Lobby, the reasoned "we'll get it next year - hearings are scheduled" stance of SEIA, and the "PV is dead" of several reporters, Boomer remains hopeful that we will survive as a vital energy option. However, I'm not sure we should put all our eggs in the tax credit basket, so I have developed a list of other measures that could be implemented to help assure our continued viability as an industry if the tax credits are allowed to expire December 31, 1985.

- 1) Reduce our production costs so that profitable prices for modules at \$3 per Watt can be offered to a large and growing market. Our government has invested over \$400 million to help bring down the cost of PV modules and the U.S. industry is investing another \$80 million this year on PV cost reduction. Two industry teams are working on single crystal silicon, one on polycrystal silicon, four on ribbon or sheet, six or so on amorphous silicon, five or so on new compounds for thin films and three on advanced concentrators with the objective of providing quality products that are less expensive. An efficient production plant in the 10 MW size (annual capacity) is badly needed to show everyone what economy-of-scale in manufacturing has to offer. Hoxan, Fuji, Sanyo and Kyocera are likely to beat us to the starting gate!
- 2) Convince Congress and DOE to support TWO SMUDS - 200 MW OF MARKET PULL. The first one-megawatt central station PV unit of the Sacramento Municipal Utility District was dedicated in July. The second phase is under contract and the third phase is "on the Hill." Let's mount a program to build the full 100 MW of SMUD, plus another 100 MW of small residential and commercial systems at the three Residential Experiment Stations. Two hundred megawatts of "market pull" will coax in the venture capital needed to get several large size production plants built.

(continued)

Boomer - continued

- 3) Make the Mavroules bill happen! Congressman Mavroules of Massachusetts got a bill passed which requires the Department of Defense to purchase PV when it is cost-effective on a life-cycle basis. Working with Defense Department officials, the Jet Propulsion Lab has identified several hundred megawatts of applications that are "economic" NOW! Prompt translation into orders would further undergird industrial activity.
- 4) Redirect nuclear breeder reactor and synfuels monies into PV initiatives. Some of the funds already in these programs could be channeled effectively into the photovoltaics effort.
- 5) Institute a DOE-funded PV manufacturing methods program. The Defense Department regularly funds pilot plants in the private sector to assure the availability of critical items needed by the Department. Such support for exploratory development brought us the transistor, semiconductor memories and integrated circuits. Let's fund, after competition, four PV pilot plants - one sheet plant, one amorphous silicon plant, one concentrator plant and one "breakthrough" film plant. On a reasonable cost-sharing basis, the total cost of four 10 MW plants could be less than \$50 million. Even two 10 MW plants would go a long way toward assuring the market availability of modules at \$3 per peak Watt.
- 6) Form a strong, well-funded PV trade association or PV Division of SEIA. Boomer paid \$500 to SEIA this year in dues from a very small consulting firm. SEIA needs five members at \$20,000 per year, ten at \$10,000 per year and 20 at \$1,000 per year working together for the good of PV. Our infantile days are over. A mature industrial association is needed. Members dues of \$30,000 from the entire PV industry won't do it. We need a PV industry association or PV Division of SEIA with at least a \$300,000 annual budget! This kind of representation in Washington, D.C. might have a chance to get action that assures a thriving U.S. PV industry that can survive in the face of growing competition from Japan, India, Europe, Saudi Arabia and other areas.

We would urge our readers to come forward with other suggestions. PV NEWS will gladly pass them on in print.

Let's act now so that 1985 will be another year of growth for the U.S. PV industry, not the start of a decline.

Boomer

-11-

Conclusion

For the U.S. PV industry to retain its dominant position in the world market, obtain sufficient profits to bring in new low cost manufacturing methods and provide the U.S. a reliable, environmentally acceptable source of electricity that is economically competitive with oil, coal and nuclear-generated electricity by 1995, we need more federal assistance than just "high risk research" and "research for research sake."

WE NEED:

- The extension and expansion of the tax credits;
- To complete the entire 100 MW cost-shared SMUD projects;
- Well funded regional Experiment Stations;
- Assistance in manufacturing process development for single crystal silicon efficiency enhancement, concentrator development and sheet production, as well as amorphous silicon.
- For the government only to follow the law initiated by this Committee and passed by a resounding majority of Congress. i.e.
To comply with the "PV Research Development and Demonstration Act of 1979."

Mr. McCURDY. Thank you, Mr. Maycock.

Mr. Little, or Dr. Little, we'll hear from you and Mr. Day first and then we'll have questions from the committee.

**STATEMENT OF ROGER G. LITTLE, PRESIDENT, SPIRE CORP.,
BEDFORD, MA**

Mr. LITTLE. Mr. Chairman, Spire Corp. manufactures and sells equipment for the manufacturing of photovoltaic cells and modules. The near-term market for photovoltaic products, since—

Mr. McCURDY. Excuse me, Dr. Little, why don't you bring that microphone a little closer to you. Perhaps people can hear better.

Mr. LITTLE. The near-term market for photovoltaics is principally international due to the low cost of energy in the United States, relative to, for instance, the Third World. The U.S. industry once dominated the international market but is now losing market share. This is in part due to the high cost of PV module manufacturing, which is making it more difficult to compete with subsidized foreign products.

In the near future, new advanced foreign production lines will make competition even tougher. To ensure the viability of the industry in the near term, the next 3 to 5 years, we need to put in place new advanced high-volume production lines. Although other incentives may be necessary to promote the industry, this testimony primarily supports Chairman Fuqua's proposal, the Federal Energy Research and Development Facilities Act of 1984.

The testimony addresses a recommendation that the Government cost-share production lines incorporating advanced state-of-the-art photovoltaic manufacturing technology. This approach is to be contrasted with subsidized photovoltaic buys which tend to use antiquated technology.

I am well aware that a number of major PV manufacturers are not supportive of this cost-share concept, however, I believe that the Federal Government should have a twofold strategy for the photovoltaics industry. First is to encourage the present participants to stay with the industry, but also to develop a safety-net strategy should there be further withdrawals by encouraging other participants.

As I mentioned, Spire Corp. manufactures and sells equipment to fabricate solar cells and modules. Over the past year, approximately 80 percent of our equipment business has been overseas. This experience reflects the scale-up of international competition in the photovoltaics arena.

While European and Japanese capability is growing rapidly with advanced technology, U.S. manufacturers have made little investment over the past 4 years to improve their manufacturing capability. The position that is encountered is that until the market expands significantly, such capital investments are not justified.

However, unless such investments are made, prices will remain high and the markets won't develop as rapidly. This is the classic chicken-and-egg situation. Government cost-shared facilities would allow the U.S. industry to break out of this dilemma.

My specific recommendation is that Federal cost-share be provided to assemble large-scale crystalline photovoltaic cell and module

production lines, using a range of silicon sheet materials, advanced high-efficiency processing technology and automated machine concepts. Much of this technology has been developed by the Federal research and development program of the past 5 years, but has not yet been employed. Examples of such line—lines would involve technology of high efficiency, primarily crystalline silicon.

Sheet materials such as advanced Cz, web, et cetera, could be used. Production levels of 30 megawatts per year should be considered. Estimated capital cost for such lines is on the order of \$40 million. Analysis shows that you can produce at approximately \$2.60 per watt with such a production line using advanced Cz techniques.

A sensitivity analysis, which is detailed in my submitted testimony, for a 30-megawatt line shows the strong effect of the cost of capital. With Federal 50-percent cost share, manufacturing costs can drop more than 20 percent at full production levels. But a second important consideration is that before market demands are such to use the full production capacity of the line, a cost-shared line allows that production line to be cost-competitive at a much lower rate. For instance, a 30-megawatt line producing at 5 megawatts per year would save \$2.60 per watt, allowing a selling price of about \$4.90 per watt, which is competitive in today's market. This is, of course, due to the fact that labor and materials are variable costs and capital is a fixed cost.

The mechanism for providing such cost-share assistance while minimizing Federal expenditures and intrusion into the marketplace can be through a competitive solicitation to industry awarding two or three production lines. As noted, these production lines would likely be based upon crystalline silicon technology, although the solicitation would also allow other demonstrated field-tested technologies to compete.

In summary, the U.S. photovoltaics industry is losing its market share due to strong foreign competition. In order to ensure the viability of the industry over the next 5-year period, substantial capital investment in manufacturing facilities will be necessary. It is recommended that the Federal Government cost-share 50 percent of cost of capital to field such production lines. Federally cost-shared production lines will result in a lower-cost product at full production capacities, while at the same time allowing cost-competitive module manufacturing at lower capacities until the market demand grows.

Thank you very much.

[The prepared statement of Mr. Little follows:]

STATEMENT OF

ROGER G. LITTLE

PRESIDENT

SPIRE CORPORATION

Bedford, Massachusetts 01730

Regarding:

Current State and Future Prospects
of the U.S. Photovoltaics Industry

September 11, 1984

Submitted to the:

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUB-COMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

1.0 INTRODUCTION

The present market for photovoltaic products is principally international due to the relatively low cost of energy in the United States. Although the U.S. photovoltaics industry once dominated, it is losing its market share. This loss is due, in part, to the high cost of PV module manufacturing, which is making it difficult to compete with subsidized foreign products. In the near future, new advanced foreign production lines will make competition even tougher.

Although the DOE program is playing a major role in the development of advanced, low-cost, thin-film PV technology, it is unlikely that thin-film modules will achieve the significant production levels needed to make the U.S. industry more competitive over the next five years. Thin-film technology will, however, play a major role in the early 1990's and beyond.

In order to ensure the viability of the U.S. PV industry in the near term, new, advanced, high-volume crystalline silicon production lines need to be put in place. These lines can produce higher-efficiency and lower-cost modules. Since existing market demands are not large enough to justify such major capital investments, a program of government cost-shared manufacturing facilities is recommended. These manufacturing facilities would likely employ technology developed by the federal research and development program, but which has not yet been commercialized.

In general, it may be necessary to employ all of the incentives, which have been proposed to promote the U.S. industry, such as extension of the solar business tax credit and implementation of the Mavroules Amendment. Also, other support such as is being addressed by the DOE Photovoltaics Export Assistance Seminar is important. This testimony, however, principally supports Chairman Fuqua's proposal, the "Federal Energy Research and Development Facilities Act of 1984", and will address the recommendation that the government cost-share production lines incorporating state-of-the-art photovoltaics manufacturing technology.

2.0 BACKGROUND:

2.1 Photovoltaics Market:

American industry has historically developed its market in the United States, then exported its products to foreign markets. Photovoltaics is an industry where this experience must be reversed. The dominant market for photovoltaic products for the next three to five years will not be at home, due to the relatively low cost of energy in the United States, but will be in other countries, especially those of the Third World. Approximately three-quarters of the world's population does not have electricity. The costs of central electric generating facilities, with associated distribution networks, can outweigh those associated with stand-alone photovoltaic power systems. The United States photovoltaic industry once dominated the international market, but it is now experiencing severe competition and is rapidly losing market share.

Spire Corporation manufactures and sells equipment to fabricate solar cells and modules. Over the past year, approximately 80% of our photovoltaic manufacturing equipment sales have been overseas. This experience reflects the scale-up of international competition in the photovoltaics arena.

As we approach the 1990's, the photovoltaic market in the U.S. is expected to expand rapidly by supplementing central grid power sources. U.S. grid requirements for photovoltaic power stations are projected to be as great as 600 megawatts in 1990 and 2000 megawatts in 1995. Unless our photovoltaics industry grows and prospers in the international market during the next five years, it will not be in a position to satisfy our own utility demands in the 90's. These needs may then be filled by foreign manufacturers.

2.2 Character of the U.S. Industry:

The U.S. industry consists primarily of large oil corporations participating in photovoltaics manufacture. These corporations have invested heavily in manufacturing technology, principally for crystalline silicon solar cell modules, during the late 70's when energy prices were escalating rapidly. Now that oil price stability has been achieved and prices are projected to be flat for a number of years, there is evidence that this industry is becoming less interested in photovoltaics.

The U.S. government position should be to encourage the continued participation of oil companies in photovoltaics, while maintaining an industry "safety net" strategy should they withdraw. The latter can be achieved through the Department of Energy research and development program employing a broad spectrum of U.S. industry. The former is best achieved by encouraging investment by the oil industries in large scale, highly efficient, crystalline silicon photovoltaic manufacturing facilities. Government cost-share of the capital associated with these facilities is recommended to encourage this investment.

2.3 Foreign Competitions:

Japan and Europe are developing their own photovoltaic industries. The European industry uses technology quite similar to our own. The companies involved are generally small and encouraged by each country's respective governments. Associated with those countries are vestiges of colonial associations in the third world, allowing each country in Europe to develop its own indigenous industry with objectives of export to these colonial associations.

The photovoltaic industry in Japan is dominated by electronic-based corporations and is expanding most rapidly. Major participants are Sharp, Mitsubishi, Sanyo, Hitachi, and Hoxan. As would be expected, the Japanese are beginning to assemble large-scale, automated, crystalline silicon production lines. Much of the technology that they are employing was developed by Department of Energy supported research in the late 70's and early 80's. The Japanese recognize the importance of the international market to their industry. In fact, Kyocera is now doing site surveys in the U.S., for the location of a crystalline silicon production line. Hoxan has announced the start of a 10 megawatt per year, totally automated crystalline silicon production line using robotics and other advanced technologies. Hoxan has publicly expressed their strategy to fabricate solar cells for shipment to Third World countries to be assembled in-country into modules.

While European and Japanese manufacturing capability is growing rapidly with advanced technology, United States manufacturers have made little investment over the past four years to improve their manufacturing capability. Their position is that until the market expands significantly, investment in manufacturing facility capital is not justified. However, unless such investments to scale-up and improve production are made, prices will remain high and markets will not develop as rapidly. This presents the classic "chicken and egg" situation. Government cost-shared facilities could allow U.S. industry to break out of this dilemma.

3.0 GOVERNMENT COST SHARED PRODUCTION FACILITIES:

3.1 Recommendations:

It is necessary to improve and increase crystalline silicon photovoltaic manufacturing capacity to ensure a place for the U.S. industry in the growing international and domestic market of the next five years. It is recommended that Federal cost-share help be provided to assemble large-scale, crystalline silicon photovoltaic module production lines using a range of silicon sheet material, advanced high-efficiency processing technology, and automated machine concepts. Much of this technology has been developed by the Federal research and development program over the past five years. By providing adequate cost share of capital, two results can be achieved:

- (1) At full production, significant cost reduction in module manufacture can be achieved.
- (2) During the period of market growth, before production-line full capacity is reached, modules can still be produced at reduced cost.

Should additional incentives of government-stimulated large-scale purchases be available, the latter consideration would not be necessary, as full production capacity would be required to meet market demands.

3.2 Production Line Descriptions:

The generic characteristics of a number of advanced photovoltaic production lines can be summarized as follows:

PHOTOVOLTAIC PRODUCTION LINES

<u>Technology:</u>	Advanced, high-efficiency crystalline silicon.
<u>Sheet Material:</u>	Advanced Cz, Web, EFG, HEM, RTR, SEMIX, etc.
<u>Production Level:</u>	30 megawatts per year.
<u>Processing:</u>	Semi-automated, all dry.
<u>Estimated Capital Cost:</u>	\$40M (current \$)
<u>Time to Full Scale Production:</u>	1.1/2 years.
<u>Cost of Module Manufacture:</u>	\$2.60 per watt (current \$) without cost share \$2.10 per watt (current \$) with cost share

Figure 1 presents a sensitivity analysis for a 30 megawatt per year advanced Cz production line. The analysis contains a considerable amount of information. The point to be made is that module cost is a strong function of capital cost. A 50% cost-share by the government in industry manufacturing facility capital investments can result in a more than 20% drop in module cost, at full line capacity.

Figure 2 presents another important consideration. Before market demands allow the line to be operated at full production, modules can be produced competitively due to the cost-shared capital. For instance, cost-share of a 30 megawatt per year production line producing at 5 megawatts per year, saves \$2.60 per watt allowing a selling price of \$4.90 per watt, which is competitive in today's market. This saving is a result of the material and labor costs associated with the manufacture of PV modules being variable costs, while capital is a fixed cost.

The assembly and operation of such production lines would provide relatively low-cost modules for utility applications, thereby increasing market development and demonstration, which would accelerate commercialization and industry growth. These modules could also be employed immediately in utility demonstration programs.

It is, therefore, recommended that the Federal government cost-share large-scale crystalline silicon manufacturing lines using the advanced technology developed under federally-supported research and development programs.

4.0 MECHANISM FOR PROVIDING COST-SHARE ASSISTANCE:

The mechanism for providing cost-share assistance while minimizing federal expenditures and intrusion into the marketplace can be through a competitive solicitation to industry for 2 or 3 such production lines. These production lines would likely be based upon demonstrated, high-efficiency, crystalline silicon technology, although the solicitation could also allow other demonstrated, field tested technologies to compete.

Such solicitations have, in fact, been used successfully on a smaller scale by the Jet Propulsion Laboratory Technology Development Program for its MEPSDU (Module Experimental Process System Development Unit) procurements.

5.0 SUMMARY:

The United States photovoltaics industry is losing its market share to strong foreign competition. In order to ensure the viability of the industry through the critical next five-year period, substantial capital investment in manufacturing facilities will be necessary. These production facilities must have high volume throughput using high-efficiency processing techniques, advanced crystalline silicon technology, and automation; much of the technology has been developed under federally sponsored research and development activities over the past five years. It is recommended that the Federal government cost-share at 50% the cost of capital to field such production facilities. Federally cost-shared production lines will result in a lower-cost product at full production capacities, while at the same time, allowing cost competitive module manufacturing at lower production capacities until market demands grow.

FIGURE 1

SENSITIVITY ANALYSIS OF MODULE MANUFACTURING COST

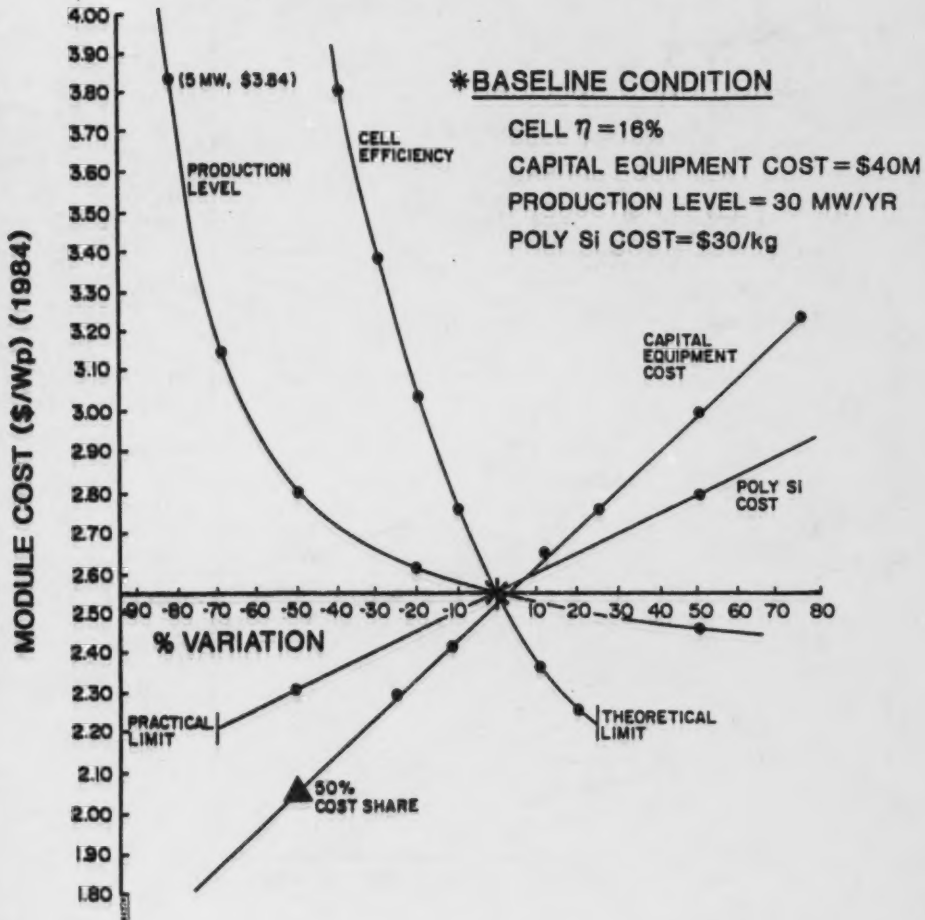
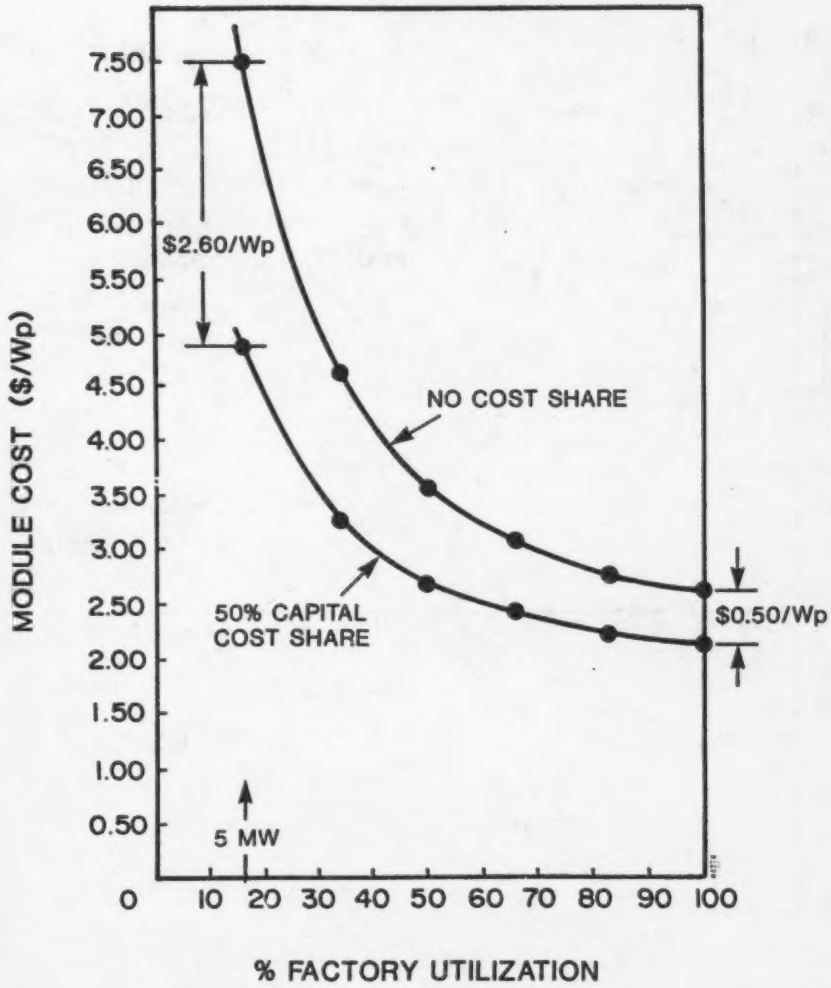


FIGURE 2

MODULE COST AS A FUNCTION OF
PLANT UTILIZATION
30 MW PLANT



Mr. McCURDY. Thank you, Dr. Little.
Mr. Day.

STATEMENT OF JOHN F. DAY III, PRESIDENT, STRATEGIES
UNLIMITED, MOUNTAIN VIEW, CA

Mr. DAY. Mr. Chairman, I have a few slides. I wonder if we could lower the screen.

Mr. McCURDY. If we can carry out this technology here.

Mr. DAY. I think we're going to—here we go. Now, the logistics here. A few mechanical problems.

Before I turn on the slide, I'd like to make a few introductory remarks, Mr. Chairman. In April 1978, I had the privilege of addressing this committee at a time of hearings for what led to certain research and development—photovoltaic research and development acts. Much has happened in the world during the past 6 years since the passage of that bill and a moment of reflection on the events can be very instructive on the actions that may be appropriate for the future.

Mr. McCURDY. The light switches are right there in a line. There you go, great, thank you.

Mr. DAY. I think I'm in the middle of it. OK. We haven't quite got this worked out yet.

During the past 5 years, since 1978 to 1983, we've seen the world has experienced oil prices that have increased from \$15 a barrel to over \$40 a barrel, then decreased back to \$26. We've seen the worst economic recession since the 1930's. We've seen an unparalleled financial crisis in the developing world, yet photovoltaics has passed through this period in dramatic fashion.

[Vu-graph.]

Mr. DAY. World unit volumes increased sixteenfold. Prices in real dollars have declined by 54 percent. The industry dollar volume has increased over sevenfold.

[Vu-graph.]

Mr. DAY. During the period, the U.S. Government policy has shifted from direct purchase of photovoltaic modules to the use of tax credits to stimulate the market. Direct Government purchases have declined from over 80 percent of the U.S. market in 1978 to only 7 percent in 1983. The Third World market has grown to over 3 megawatts by 1983. In 1984 alone, the Egyptian military will purchase almost as much PV as the world industry produced in 1976.

Mr. McCURDY. Mr. Day.

Mr. DAY. Yes.

Mr. McCURDY. Pardon me just a moment. We're going to—why don't you move your chair on this side of the table and that way, everyone else can see the screen. Here's a chair. Very good. We have a lot of people here wanting to see your—

Mr. DAY. Perhaps I should sit in front of the slides.

Mr. McCURDY. Thank you.

Mr. DAY. OK.

Now I need—Mr. Chairman, may I stand up?

Mr. McCURDY. That will work, too, if that'll reach. Just turn it around.

Mr. DAY. Can you hear me OK? Do you have an alternative? Can you hear me?

Mr. McCURDY. We can hear you, if the reporter can. I think so. Go ahead and try.

Mr. DAY. Can you hear me OK?

The REPORTER. Yes, sir.

Mr. DAY. OK. Fine.

Mr. McCURDY. I think if you just speak up, we'll—

Mr. DAY. I wanted to review the 1983 flow of product around the world. This figure illustrates that the U.S. renewable energy tax credits have had a very significant role in the current production volume of the U.S. industry, accounting for approximately 57 percent of the total installations by U.S. suppliers during the year. In addition, the Government-supported utility-scale project at the Sacramento, CA, Municipal Utility District accounts for a significant element of the Government procurements during the year.

The key Government photovoltaic programs have been important to stimulate this industrial growth, particularly the tax credit, the advanced R&D and technology-development programs, the demonstration programs and, of course, the first utility-scale photovoltaic project.

The benefit of these programs has allowed American industry to improve their production efficiencies, raise the quality of their product and lower the product cost. Lower prices have begun to open new markets, especially in export areas around the world.

[Vu-graph.]

Mr. DAY. Within the United States only, the photovoltaic industry and its supporting suppliers and distributors include approximately 95 companies—I have 96 on the chart—and their supporting—let's see, with over \$345 million in aggregate sales. This represents between 4,000 and 6,000 jobs.

The photovoltaic electric power systems have established their technical viability around the world. The growth of the market and the advance of this technology has not gone unnoticed by other countries. Competition with American companies has grown steadily. In the past 5 years, major photovoltaic R&D programs have been increased in Japan, Germany, France, Italy, and a number of other countries. Today, photovoltaic products are manufactured by over 80 companies in 17 different countries.

The competition has led to an erosion of the U.S. market share, from approximately 90 percent in 1978 to approximately 60 percent in 1983.

[Vu-graph.]

Mr. DAY. Without the benefit of the tax credits—well, Mr. Chairman, this chart, this slide shows the total aggregate world market over the last 6 years. The United States market share is shown in 1977 to be about 92 percent, declining to about—well, it shows 40—I'm sorry, 62 percent if one includes the tax credit-motivated investments. Without the tax credit-motivated investments, the U.S. market share is about 48 percent of the world.

[Vu-graph.]

Mr. DAY. Now, like 1978, 1984 is another time for resolute action, but action required today is different than the actions required in 1978. It is my opinion that greater priority must be placed upon

stimulating commercial channels, especially for export, than was provided over the past 5 years.

[Vu-graph.]

Mr. DAY. In particular, I would like to offer the following series of recommendations to the committee in the following areas: I have recommendations in export finance; an education program; tax credits for utilities; tax credits for consumers; the Government use of photovoltaics; advanced R&D and technology development; a commentary on AID procurements; I am opposed to the investment in advanced production facilities; I am in favor of subsidizing sales expenses for export; and then—here and in this is my feeling that the largest element of any saving that could be derived from reduced spending on the Synthetic Fuels Program should go toward reducing the deficit and a move toward balancing the budget.

Now, I'd like to comment on a selected set of these options.

[Vu-graph.]

Mr. DAY. First, the export credit issue. A revolving fund should be created within the Export-Import Bank for the specific purpose of cofinancing or subsidizing interest rates on export sales of U.S. photovoltaic manufacturers. The fund should be set aside to provide lower interest rates for a set period—perhaps 5 years—but a built-in sunset provision would withdraw the subsidy after that time.

Eximbank should provide expedited paperwork processing for credit approval, especially on smaller orders. Advanced approval of financing packages, lines of credit, and ceiling risk limits by country could be of considerable benefit to suppliers. The fund should be revolving, such that funds are repaid, new funds—as funds are repaid, new funds become available for new projects.

Subsidized export financing provides the greatest leveraged benefit to the industry. Since a small amount of money can be multiplied from the funds from traditional commercial trade channels, a small sum of money properly applied can allow the buyer to make the best long-term decision, rather than be forced into a short-term decision because of current cash limitations.

[Vu-graph.]

Mr. DAY. Financial assistance is a type of cost sharing with the recipient that builds industry infrastructure through experience. Trained people are developed throughout the world who will be there in years ahead to handle future commercial business. Because of lower, often subsidized interest rates around the world, American suppliers are at a disadvantage in financing their customers relative to the position of suppliers in other countries. Interest rate subsidies are one step to move American companies into a position of parity with competing OECD countries.

The greatest competitive export problem that the U.S. photovoltaic industry must overcome is caused by the strength of the dollar. Over the past few years, while photovoltaic prices have declined in dollar terms, the dollar on world markets has actually gone up by over 40 percent. Interest rate subsidies are a small step to overcome this problem.

[Vu-graph.]

Mr. DAY. Education. Mr. Chairman, I'm going to defer any comment on this slide, but the fact is that if funds are provided by Ex-

imbank, a small percentage can go to make a very large—large change in the flow of exports. There is a multiplying effect tied to the interest rate—a 5-percent reduction gives you a 20-to-1 multiplier in the amount of funds that can—that can lead to exports. So that there is a built-in multiplier here.

[Vu-graph.]

Mr. DAY. I want to point out one thing on export competition. If we look at the activities of other countries today, there are both direct subsidies and indirect subsidies. We find that direct subsidies in the form of 50 percent of sales and market expenses are already being paid by European and Australian companies. It is more economic for American companies with Australian subsidiaries to have their Australian companies actually do the export trade because 50 percent of their sales expenses are covered by the Australian Government.

Indirect subsidies in the form of export financing or cofinancing with AID funds, or AID-equivalent funds, are common from Japan, France, and other OECD countries. My point—the American companies are at a disadvantage. My recommendation is only to put them on a parity with other practices that are in place in the market.

I'll return to the text. I'll comment that the educational program should be focused on the education of foreign service officers and the foreign government officials around the world. We need to remove the mystique from photovoltaics. It works. It is here now and it is economic in the right set of circumstances today.

Direct educational efforts toward these officials can be meaningful undertaken by the Federal Government.

I will endorse what I have said before that I think tax credits should be extended. I would like that tax credits be extended to the utility industry. This is the industry that provides our electricity and could eventually become a major consumer of photovoltaic power.

Tax credits for the consumer. The Government use of photovoltaics—I'm skipping through in order not to stretch the testimony.

I endorse advanced R&D. I have a commentary on the procurement for foreign assistance, and reiterating my issue on the subsidy of export slot—of export sales expenses.

I want to close with one comment. If the market continues to develop as a broadly based and sound commercial business, there will be no shortage of funds for capital investment in new plants and equipment. Private industry only withholds investment funds if it questions the market or feels that the Government is going to provide the investment funds.

Government subsidies tend to attract companies that specialize in doing Government contracts. This may be acceptable if the Government is the end customer, as in the case of military procurements. However, where the Government is not the end consumer, knowledge of commercial markets is mandatory. Often, Government contracting companies are companies without the knowledge, resources, or inclination to be successful in a commercial market.

In the case of photovoltaics, the forces in the market need to be encouraged and fostered, not undercut. To subsidize sales expense

encourages the forces of market and leads to longer term industry infrastructure development.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Day follows:]

TESTIMONY OF
JOHN F. DAY III
President
Strategies Unlimited

before the

HOUSE SCIENCE & TECHNOLOGY COMMITTEE
ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE

September 11, 1984

Mr. Chairman, Members of the Committee:

In April of 1978 I had the privilege to testify before your committee on another Bill concerning the photovoltaic industry, the "Photovoltaic Research and Development Act of 1978". Much has happened in the world during the past six years since the passage of that bill, and a moment of reflection on these events can be very instructive on the actions appropriate for the future.

During the five years between 1978 and 1983 the world has experienced:

- Oil prices that increased from \$15 a barrel to over \$40, then decreased back to \$26.
- The worst economic recession since the 1930's
- An unparalleled financial crisis in the developing world.

Yet photovoltaics has passed through this period in dramatic fashion:

- World unit volumes increased 16 fold
- Prices in real dollars declined by 54%
- Industry dollar volumes increased over 7 fold.

During the period the US government policy shifted from direct purchase of photovoltaic modules to the use of tax credits to stimulate the market. Direct government purchases declined from over 80 percent of the US market in 1978 to 7 percent of the US market in 1983. A third world market has grown to 3 MW by 1983. In 1984, the Egyptian military alone will purchase almost as much PV as the world industry produced in 1976.

The worldwide flow of product distributed in 1983 is presented in Figure A. This figure illustrates that the US Renewable Energy Tax Credits have played a significant role in the current production volume for the US industry, accounting for approximately 57% of the total installations by US suppliers during the year. In addition, the government-supported utility-scale project at the Sacramento (California) Municipal Utility District accounted for a significant element of the government procurements during the year.

Key government photovoltaic programs have been important to stimulate this industrial growth, particularly:

- Federal Tax Credits
- Advanced R&D and Technology Development Programs
- Demonstration Programs
- First Utility Scale Photovoltaic Project.

The benefit of these programs has allowed American industry to improve their production efficiencies, raise the quality of their products, and lower their product costs. Lower prices have begun to open new markets, especially in export areas around the world.

Within the US only, the photovoltaic industry and its supporting suppliers and distributors include approximately 95 companies accounting for over \$0.3 billion in annual sales and representing between 4,000 and 6,000 employees.

Photovoltaic electric power systems have established their technical viability around the world. The growth of the market and the advance of this technology has not gone unnoticed by other countries, however. Competition with American companies has grown steadily. In the past five years major photovoltaic R&D programs have been substantially expanded in:

- Japan
- Germany
- France
- Italy

as well as in a number of other smaller countries. Today, photovoltaic products are manufactured by over 80 companies in 17 countries.

This competition has lead to an erosion of the US world market share from approximately 90% in 1978 to approximately 60% in 1983. Without the benefit of the "tax credit driven projects", the US market share would be approximately 48% of the world production.

The difficult position of the US suppliers has been compounded by the rising value of the dollar on international markets and the high interest rates. Since photovoltaics is a capital intensive method of generating electricity, interest rate variations become a significant variable for the buyer in comparing alternative technologies.

But a new cloud is now on the horizon. Tax Credits expire the end of 1985. Concerns have appeared throughout the industry over the future viability of the industry. Can commercial markets be expanded sufficiently rapidly to fill the void created by the withdrawal of tax credits? Already a few companies have chosen to withdraw from the business. A number have undergone major refinancing in order to continue their growth programs.

Like 1978, now is another time for resolute action. But the action required today is different than the actions required in 1978. It is my opinion that greater priority must be placed upon stimulating commercial channels, especially for export, than was provided over the past five years. In particular, I would like to offer the following series of recommendations to the committee in the following areas:

- Export financing
- Education
- Tax credits for utilities
- Tax credits for consumer and third party arrangements
- Government use of photovoltaics
- Advanced R&D
- Procurement for foreign AID recipients
- Subsidize export sales expenses.

Each of these elements is discussed below:

1. Export Financing

A revolving fund should be created within the Eximbank for the specific purpose of co-financing or subsidizing interest rates on export sales of US photovoltaic manufacturers.

- Funds should be set aside to provide lower interest rates for a set period, perhaps five years, but a built-in "sunset" provisions should withdraw the subsidy after that time.
- Eximbank should provide expedited paperwork processing for credit approvals, especially on smaller orders. Advance approval of financing packages, lines of credit, or ceiling risk limits by country could be of considerable benefit to suppliers.
- The fund should be revolving, such that as funds are repaid, new funds become available for new projects.

Subsidized export financing provides the greatest leveraged benefit to the industry, since a small amount of money is multiplied by the funds from traditional commercial trade channels. A small sum of money properly applied can allow the buyer to make the best long-term decision, rather than be forced into a short-term decision because of a current "cash bind".

Financing assistance is a type of cost sharing with the recipient that builds industry infrastructure through experience. Trained people are developed throughout the world who will be there in years ahead to handle future commercial business.

Because of lower, and often subsidized, interest rates around the world, American suppliers are at a disadvantage in financing their customers relative to the position of suppliers in other countries. Interest rate subsidies are one step to move American suppliers into a position of parity with competing OECD countries.

The greatest competitive export problem that the US photovoltaic industry must overcome is caused by the strength of the dollar. Over the past few years, while photovoltaic prices have declined in dollar terms, the dollar on world markets has actually gone up by over 40%. Interest rate subsidies are a small step to overcoming this problem.

2. Education Program

The government could undertake a meaningful worldwide education program to raise the awareness of photovoltaics and its economic viability.

- Focus educational efforts to raise awareness of photovoltaics among US foreign service officers and other foreign government officials around the world. We need to remove the "mystique" from photovoltaics — it works, it is here now, and it is economic in the right sets of circumstances.
- Direct educational efforts towards:
 - US foreign service officials
 - Officials of foreign governments, especially power authorities, rural development officials, education offices, military, and communications establishments
- Provide seminars and training for foreign dealers and distributors in system sizing, installation, and maintenance

3. Tax Credits for Utilities

The current expiring tax credits should be extended. But more than being extended, their coverage should be expanded to include the US utility industry, the industry that provides our electricity and that could eventually become a major consumer of photovoltaic power.

- Provide tax credits to US utilities for investments in renewable energy technologies
- Incorporate a "Buy American" clause for tax credit qualification.

4. Tax Credits for Consumer and Third Party Arrangements

- Current credits, which expire the end of 1985, should be sustained for private homeowners, ranchers, etc.

5. Government Use of Photovoltaics

- Encourage the Mavroules Bill for DOD evaluation of photovoltaics
- GSA standards should be routine for use by Dept of Interior, Park Service, etc. for domestic use
- Sustain the SMUD project to completion. I question the merit of an additional SMUD project.

6. Advanced R&D

- Continue support for advanced R&D and technology development, especially on a cost-shared basis.

7. Procurement for Foreign AID Recipients

- Keep the government out of the procurement business for foreign applications.

The method of procurement for AID should be examined. AID should not be purchasing and giving installations away. The most efficient use of funds would appear to be to provide the funds directly to the developing countries and let the countries make the choices from among American suppliers. As an alternative, use AID funds to subsidize commercial interest rates or as co-financing funds to assist needy countries in obtaining systems. We should leverage AID funds.

The process of acting as purchasing agent for developing countries, although well intentioned, is an inefficient method of providing assistance as too many funds are lost through project administration or unnecessary government specifications. Further, the resulting transaction does not develop infrastructure for continuing trade to serve the recipient country on a continuing basis to the degree possible from a commercial transaction.

There are plenty of needs around the world for education and technology training for AID without AID also getting into the procurement business. It seems inconsistent that at the same time the Egyptian AID office is embarking on a three year study of the applicability of photovoltaics to the Egyptian situation that the Egyptian Army has ordered for immediate delivery more than twice the volume of product planned by AID.

8. Subsidize Export Sales Expenses

Government funds could be better used to subsidize international sales expenses, including travel and demonstration inventory carrying charges, than to subsidize capital investment in new plants and equipment. A 50 percent subsidy on sales development is already a common practice among European and Australian photovoltaic companies. Terms normally call for repayment of the subsidy if a new market is opened successfully. Such a policy would only serve to put American suppliers on a parity with their European competitors.

John F. Day III

-6-

September 11, 1984

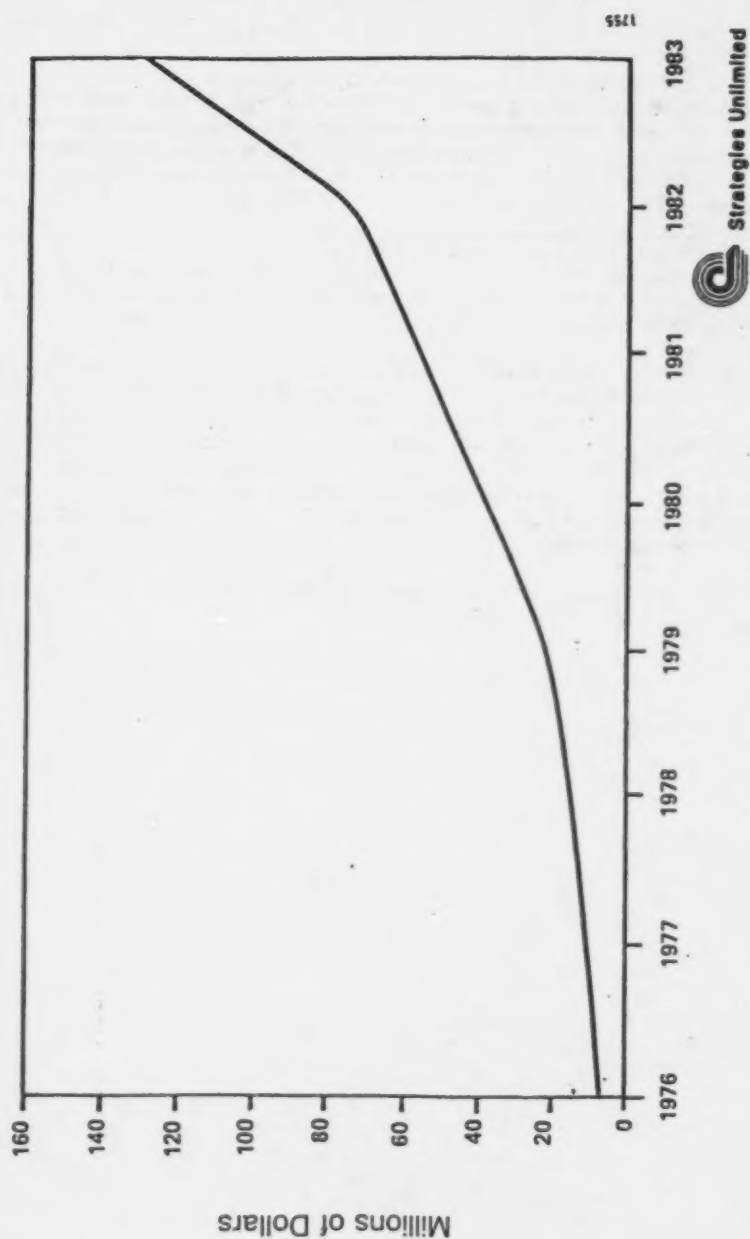
In an industry that already has excess capacity and high price competition, there is greater need to develop the sales and distribution channels for the product than there is to expand production facilities. Broader markets with higher sustained volumes will encourage economies of scale, foster price competition and force suppliers constantly to improve productivity, improve technology, and lower prices.

If the market continues to develop a broadly-based and sound commercial business, there will be no shortage of funds for capital investment in new plants and equipment. Private industry only withholds investment funds if it questions the market or feels that the government is going to provide the investment funds.

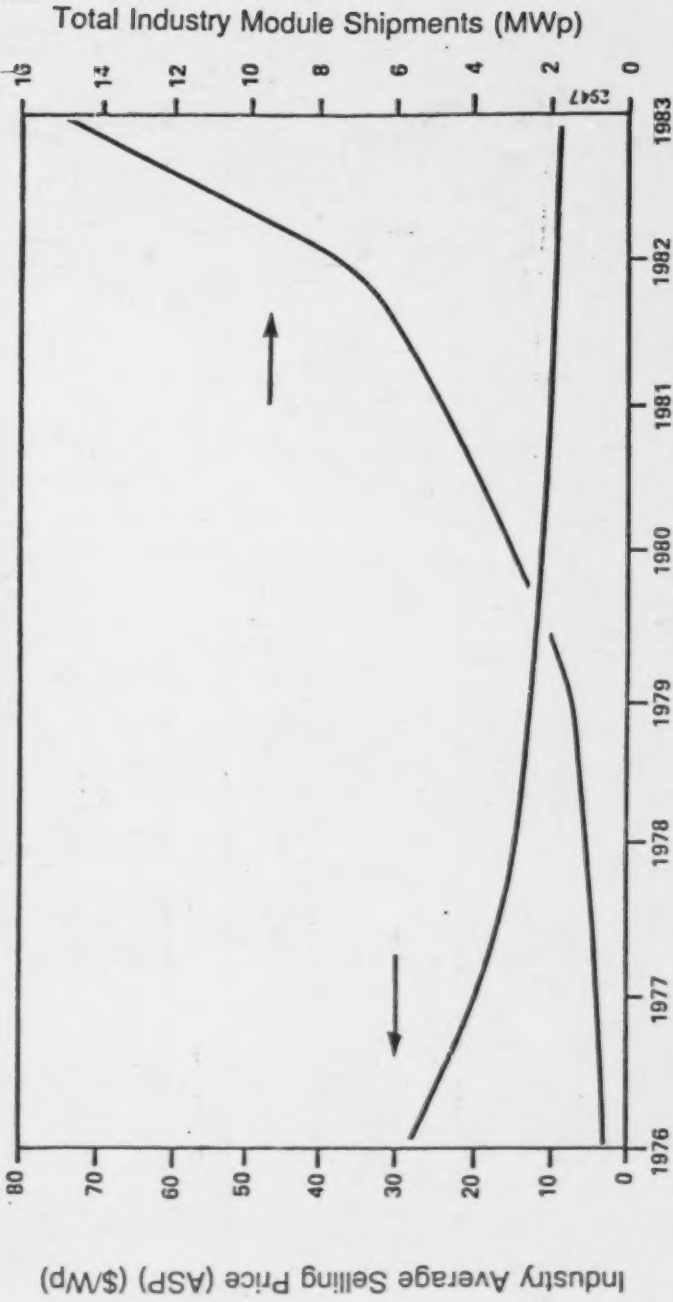
Government subsidies tend to attract companies that specialize in doing government contracts. This may be acceptable if the government is the end customer, as in the case of military procurements; however, where the government is not the end consumer, central government planning has never been as successful or as efficient as the forces of the market. In the case of photovoltaics, the forces of the market need to be encouraged and fostered, not undercut. To subsidize sales expense encourage the forces of the market and leads to longer term industry infrastructure development.

Thank you for your attention. I am now prepared to entertain your questions.

Worldwide Module Shipments

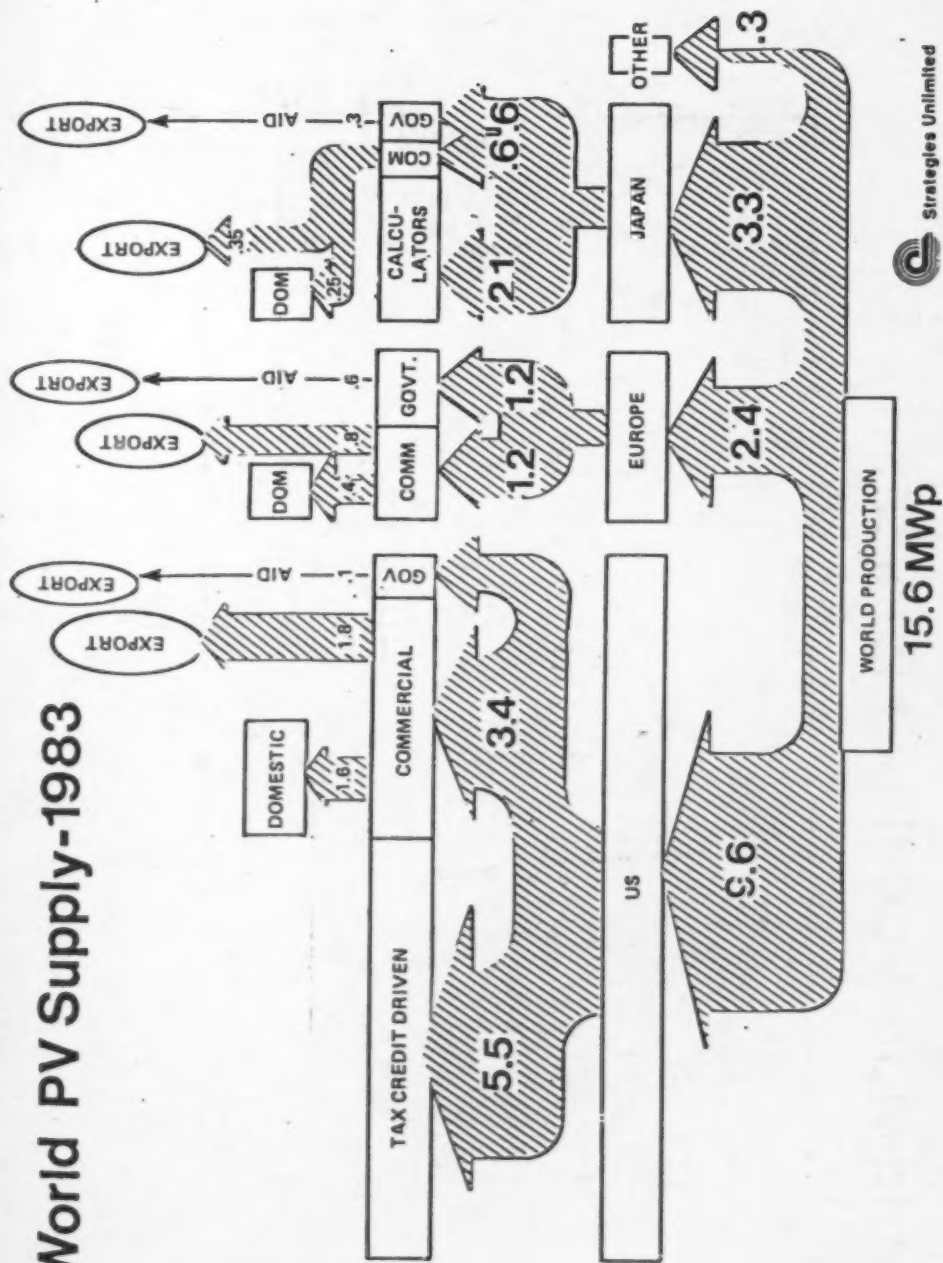


Worldwide Module Shipments



Strategies Unlimited

World PV Supply-1983



Strategies Unlimited

U.S. Photovoltaic Industry

	NUMBER OF COMPANIES	1983 SALES (EST)* \$170 MILLION
SYSTEM INTEGRATORS	45	
MODULE MANUFACTURERS	11 CURRENT SUPPLIERS 12 MAJOR R&D PROGRAMS	76 MILLION 25 MILLION
MATERIAL SUPPLIERS	5 MAJOR SUPPLIERS 6 MAJOR R&D PROGRAMS	25 MILLION 5 MILLION
MANUFACTURING EQUIPMENT	5	4 MILLION
BOS COMPONENTS	12	40 MILLION
- POWER CONDITIONING		
- BATTERIES		
- SMALL SYSTEMS		
ESTIMATED EMPLOYMENT	96 COMPANIES 4 TO 6,000 EMPLOYEES	\$345 MILLION

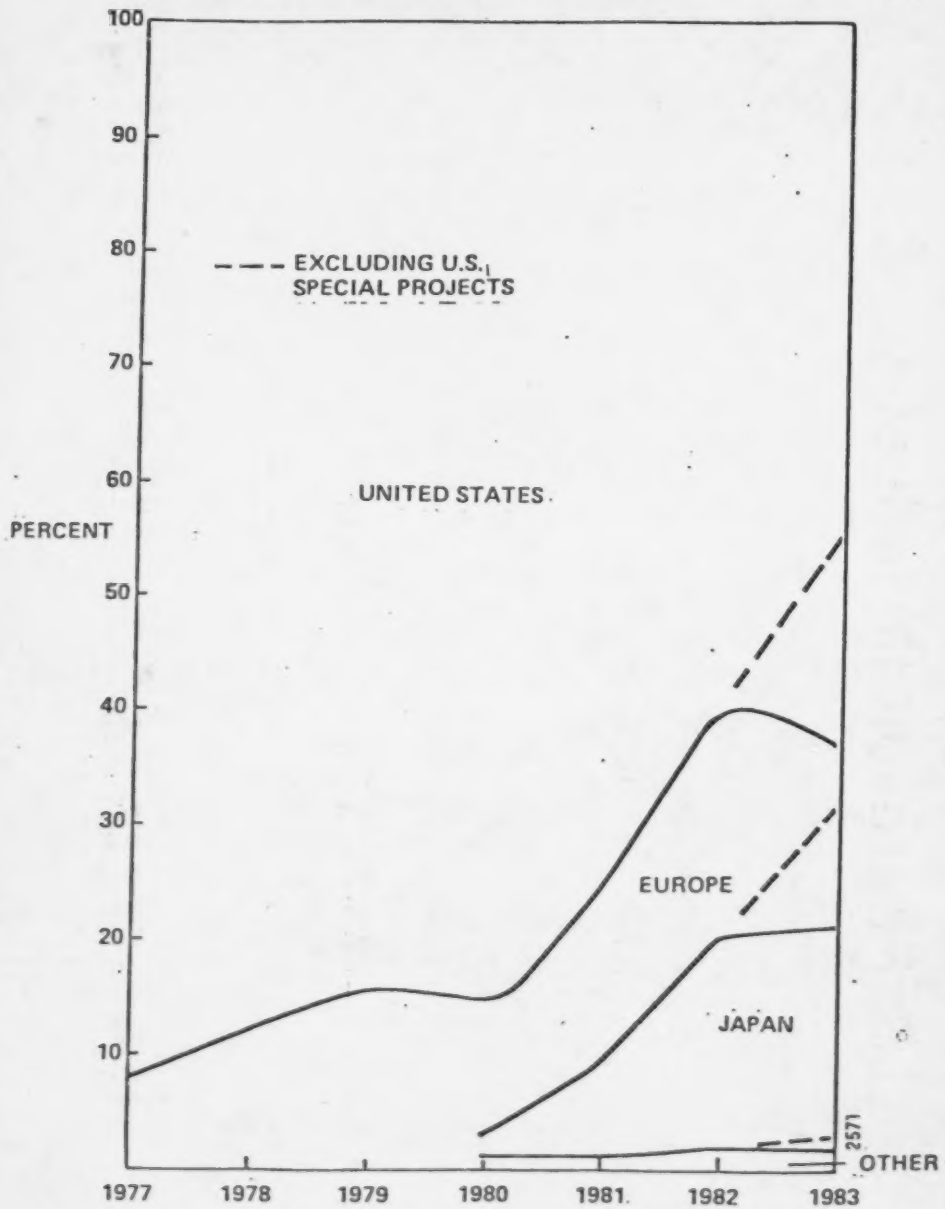
*SALES ESTIMATES DO NOT INCLUDE PRIVATE INDUSTRY R&D INVESTMENT WHICH IS ESTIMATED TO BE APPROXIMATELY AN ADDITIONAL \$75 MILLION.



Strategies Unlimited

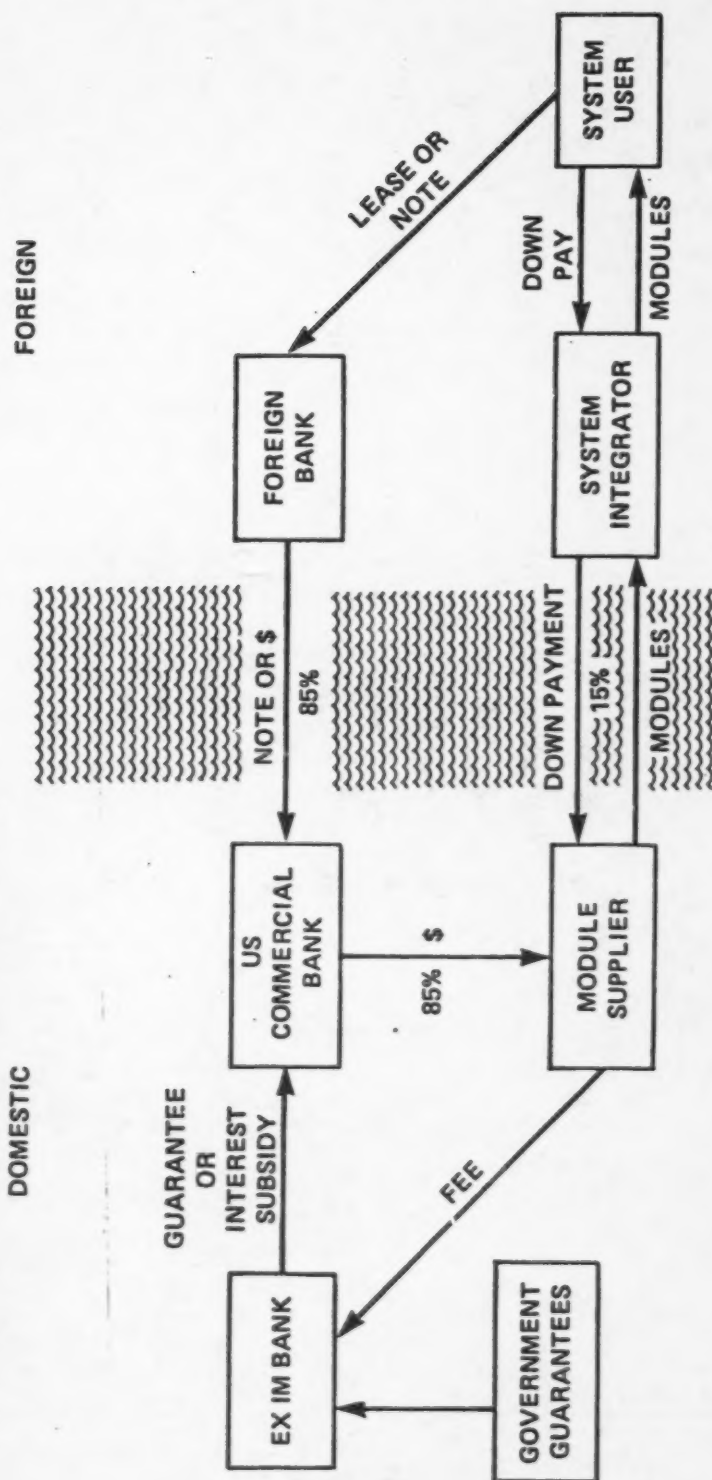
Worldwide PV Shipments

Supplier Market Share — kWp



Export Financing

45



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Recommendations

- EXPORT FINANCING
- EDUCATION PROGRAM
- TAX CREDITS FOR UTILITIES
- TAX CREDITS FOR CONSUMERS
- GOVERNMENT USE OF PHOTOVOLTAICS
- ADVANCED R&D & TECHNOLOGY DEVELOPMENT
- NO AID PROCUREMENTS
- NO ADVANCED PRODUCTION FACILITY FUNDS
- SUBSIDIZE SALES EXPENSES
- BALANCE THE BUDGET



Mr. McCURDY. Thank you, Mr. Day.

I think from the testimony—from the panel this morning, it is clear there appears—there is an obvious range of disagreement between some of the panelists as to what the Government should be doing if it does anything at all and perhaps because that jumped out most rapidly, I might ask a couple questions first of Mr. Little and Mr. Day and certainly Mr. Maycock may respond if he so desires.

First of all, from a more basic standpoint, we keep talking about international markets and we talk about Third World development. Can you give us a quick, and maybe dirty rundown of what are some of the potential markets. Who would use them; where are the Japanese and Europeans going directly? Where do you see the markets as actually developing? Are they—you say—we keep talking about AID subsidies in markets—of course, that's the traditional Third World countries that use that—underdeveloped nations.

What—do you have some specific examples of some of those key markets or key—who are buying these things?

Mr. DAY. Mr. Chairman, with your indulgence, I've got another slide.

Mr. McCURDY. OK. That's fine. Or do you have a summary that you can read off or—

Mr. DAY. The slide is a complete recitation, but the—the fact is that the market divides into generally remote power applications. We find communications to be the largest single application today in terms of commercial activities. Now, I'm setting aside the tax credit programs.

In commercial applications, it's taking the form of power for remote repeaters, for television, for UHF, VHF, for military communications. We're finding it for water pumping, for cathodic protection, which is the protection against corrosion on pipelines. We're finding remote power for second homes. In particular, the isolated—surprisingly, in Norway and Scandinavia, there's a—and Spain—we have a modest market for the wealthy family that has a remote cabin. California, the same is true. We have a number of people who choose to live off the grid and who have created a modest market. About 40 percent of the business in California is residential consumer oriented.

In terms of Third World, we're seeing first the same applications: communications, water pumping. We have something we call village power which includes remote refrigerators for vaccine. We've seen that occur in Mexico and Africa. In Indonesia, we're seeing a number of communications heavily dominated there. It's really—if you'll notice the curve that I showed earlier, a very substantial portion of the output of both Europe, Japan, the United States, is going into export and it's a Third World remote power market.

Mr. Chairman, one footnote here so that you understand, at today's prices, we are not yet low enough to open or to displace the grid equivalent in the Third World, but we are not far away. If you look at—25 percent of the grid, for example, in a country like Indonesia is powered by diesel generators. Diesel happens to be one of the most expensive forms of electricity. It is the market that is the most near to photovoltaics. It is the developing country grid-related bulk power.

Mr. MAYCOCK. Mr. Chairman, I'd like to comment on that if I may.

The key sector that John has just described is the diesel-provided electricity market. The other sectors are our present market, the communications market, the remote signaling, the remote small, but when we start to do something for the economy of the developing world, they also must conserve oil and affect their balance of payments.

Photovoltaics has a unique problem. If we are fully economic for the 5 million diesel generators that are operating in the outback of the free world; if we are economic, that means that if we have an economic life of 20 years, that we're asking the developing world to pay 20 years worth of oil in order to buy a piece of capital that uses no oil, and that leads to what Mr. Day has described as the absolute mandatory role is to provide the financing, because clearly, if you take a developing country that is short of finance, is being bled dry by the oil imports that they have to do, and then we ask them to buy economic photovoltaics, but, oh, by the way, it costs 20 years worth of oil imports because it's a 20-year product and it's fully economic, the cash-flow begins to be exacerbated on the negative side.

So, the key issue in developing the energy-conserving, oil-conserving part of the developing world market is finance. And so banking, World Bank, AID, low-interest loans, et cetera, are probably the most critical element in pushing this market forward.

Now, the other option, as Spire Corp. and others are doing, is to transfer the technology to the developing world so that they can manufacture their own photovoltaic equipment and thereby provide a balance-of-payments positive from photovoltaics right from the start.

Mr. McCURDY. Is that being done? Are you saying some countries—

Mr. MAYCOCK. Yes, sir, and I guess Mr. Little could comment on some of his successful projects.

Mr. LITTLE. We do sell equipment to the developing world. I'd much rather sell it to the U.S. industry, however. It's a lot easier.

I think the international market's been addressed adequately. If there are other questions, I'd be happy to try to respond.

Mr. McCURDY. OK.

We—back to the original point that you had suggested, the cost sharing by the Government for capital formation or for production facilities with United States and Mr. Day, specifically, said he was opposed to that type of cost-sharing program and his emphasis was more on the export stimulation.

Do you care to rebut or comment on that?

Mr. LITTLE. Well, clearly I'm a capitalist. I don't—I think we have to appreciate some things about this business which are different than the U.S. industry has experienced in the past. Mainly, it's an international business and in order to pursue that business, you have to compete in a different world. This is not a street corner gasoline war. I mean, we're fighting Japan, Inc., et cetera. To do so, you really have to encourage our own industry to make the investments needed to be competitive internationally.

The fact is, they are not. There haven't been any substantial investments made in the current technology since the late 1970's, so how do we encourage that? I addressed it in my testimony, the chicken-or-egg situation. We need to get large-volume production to get the cost down to expand the market.

We're not going to add a megawatt a year to a 5-megawatt line and get anywhere. You've got to bite it off and put in a big line to get the cost down. There's no market to justify that. Government cost share could encourage that investment. That's my—that's my point.

Mr. DAY. Mr. Chairman, over the last 8 years, the private industry of the world, not just the United States, has made an investment in photovoltaics approaching about \$800 million. It exceeds the aggregate business in terms—of you take the Government investment; you take the trade; you still find that private industry has been stepping forward making substantial investments in this business. Last year, the rate was about \$220 to \$240 million.

Now, I am of the opinion that if the market was secure; if the market future was clear; if there were vehicle mechanisms to sustain that market and to keep the trade going in a positive way, private industry would be more than willing to make the investments that are necessary in new plant and equipment. They're certainly making the investment in advanced R&D.

Now, I don't want to take away from the Government programs for advanced R&D or technology development. Those programs have been in place for the last—I don't know, 6 to 8 years, and they have been a very successful program, and a lot of the technology that is in the factories today had its origin in some of these programs. I think we must sustain a reasonable Government development program, but over the past few years, we have not supported our commercial side to the degree that I think we should in the coming 5 years.

Mr. LITTLE. I would just like to add one comment. I think these big investment numbers need to be dissected. In terms of production capacity, they are much, much smaller. There's been a lot of investment in research, but that's not capital investment.

We need to increase the production capacity in this country, increase the—improve the techniques by which things are produced. I would guess that production capacity for the products that you see on the market today has not received more than \$20 to \$25 million worth of investment over the past 3 years.

Mr. McCURDY. Being a member from an oil-producing State, maybe I ought to ask this. Do you feel—again for the record, a more basic question—that the interest demonstrated by the Japanese and by the European nations is clearly that of an importing—importing countries from the energy standpoint, or is it some long-term strategy for what they see the potential markets to be, or are they just out developing jobs programs for their industry? What's the—what's the rationale for their—their keen interest in this area?

Mr. MAYCOCK. You have to look at the Japanese need and the Japanese environment independent of the European need and environment. The Japanese presently generate 60 percent of their electricity from imported oil. The present price of electricity in Japan

averages 12 cents a kilowatt-hour, as opposed to our presently roughly 7 cents a kilowatt-hour on a national basis.

Japan has very little other options than nuclear and solar. They have some hydro. They're working extensively on fuel cells; they're working on the possibility of coal gasification, but when it comes to natural resources, there are really only two options to displace the oil—to displace the oil are nuclear and solar.

Just as in the United States, their nuclear industry has ran into—has run into rather massive popular dissent and is beginning to slow. So they initiated Project Sunshine with the one intent was to displace oil and they have done a relatively decent job of supporting their industry in requiring their industry to deliver on time to their cost and technical targets.

Mr. McCURDY. What percentage of the Japanese industry is their market internal versus—or domestic versus foreign?

Mr. MAYCOCK. Being as—that was the second point. Being as clever as they are, they decided that their internal market would not be economic until photovoltaics was down around \$3 a watt installed, just as we found in the high-cost areas of southern California at 12 cents a kilowatt-hour, the economics works out about the same, and with photovoltaics at \$15 to \$30 a kilowatt-hour in 1978—or \$15 to \$30 a kilowatt in 1978 when they started their program, they decided that it'd be awfully nice if they could find a profitable consumer market and, lo and behold, out jumped the PV-powered calculator which went from virtually zero units in 1977 in a 110 million market to approximately 70 million photovoltaic-powered calculators this year in a 120 million unit market.

And I might add that they sold to those to begin with at a very profitable price and it's my estimate that Sanyo and Fuji have enjoyed some profits in their photovoltaic consumer product area. Having a profitable base, the industry has rewarded those managers with more R&D funds, more capital and more growth. And their stated goal is to provide electricity in Japan on something like 60 million roofs at 12 cents kilowatt-hour or less.

Their present market is consumer products and the communication area, which John has described. But their fundamental national strategy is to have an alternative source of electricity generation other than imported oil, whereas we do not have a fundamental national strategy with respect to photovoltaics at the moment.

Mr. McCURDY. Well, finally, I think we've gotten to the key point of the case, as they would say. Will we ever develop a national strategy and is it in our interest, because of our domestic supplies, to develop one? I'm asking you a loaded question, but I think for the record we need to have that.

Mr. MAYCOCK. Only if we can make photovoltaics truly economic against burning oil, against burning alternative fuel—coal, which we have an abundance—and have other owner benefits will a true American market be developed. The good news is that if the photovoltaic corporations meet the objectives that have already been established in the research laboratories of the country and can be put into place in terms of manufacturing capacity, photovoltaics can provide, without Federal subsidy, electricity at cost below that of coal and/or nuclear for the intermediate and peaking-generated option.

I don't think any of our analysts would disagree with that. So the answer is, photovoltaics is one option—and there are several others—that gives us an alternative to oil, an alternative to coal with its incipient environmental impacts and an alternative to nuclear.

It is not a panacea, but it is an alternative and I would suggest that by the year 2000, that alternative would be an incredibly valuable insurance policy for the Nation.

Mr. McCURDY. Do you believe the domination of the photovoltaic industry by the oil company subsidiaries has been beneficial or problematic for the technology, because our next panelists represent—

Mr. DAY. Mr. Chairman, the oil industry has provided the largest percentage of aggregate investment in photovoltaics over the history of the industry. Without their investment, the state of the technology would be a number of years behind its present state. I think it has not been problematic. I think it has been very constructive and I think it continues to be so.

Mr. MAYCOCK. I'd like to respond to that, too, Mr. Chairman. I totally agree with John. There is this incredible paranoia that if big oil does it, there must be something hidden. There is no hidden agenda in my opinion in the oil support of photovoltaics. They're in the energy business and this is one of the many options that they're doing intense investment, difficult technical research with the most credible scientists in the country, and doing their darnedest to establish photovoltaics as a viable industry.

There is a risk in that they will spend big bucks, generate large staffs, generate incredible marketing organizations and there is a possibility that they could very quickly get disenchanted with the option.

At the moment, we're seeing increasing risk capital from the oil companies, despite the recent layoffs at the two oil company-funded areas. The layoffs, in my opinion, were eliminating excess baggage and have been a tightening and a good management role for the companies and I hope it can lead to profitability.

If the oil companies can gain profits from photovoltaics, as John has stated, we will see an incredible increase in risk capital and an incredible risk—increase in the American capability. So, I can see no reason to worry about the oil company support, provided the environment is one of good business.

Mr. LITTLE. I am certainly in favor of the oil companies being in photovoltaics and my only concern's they stay with it. And in order to do so—and I think that we've got to encourage them to invest in capital—not risk capital and not R&D and all those funny things, but capital capital. I mean, get the production lines up and I would like then to think that the proposal I presented here had some merit. But we certainly need to mend the photovoltaics industry.

Mr. MAYCOCK. One other comment, Mr. Chairman, very quickly. There's another side to the coin and let us not forget that Chronar Corp., Intersol Corp., Spire Corp., United Energy Corp.—No. 2 producer in the United States—have all done this without oil company money and I think you're going to hear a very exciting story from these companies, too. So it's not just a completely oil-dominated in-

dustry in terms of the technology flow and the risk capital that's being allocated.

Mr. McCURDY. Very good. Thank you.

Gentlemen, thank you very much for a very enlightening session. Please remain for the other panels if you wish. We'd love—if you have other comments—to hear those, but at this point, we will have Mr. James Caldwell, president of ARCO Solar, Inc.; Mr. John Corsi, president of Solarex Corp.; and Mr. Ernest Lampert, president of United Energy Corp.

If those gentlemen are available—gentlemen, welcome. We appreciate you taking time out of your busy schedules to appear at this hearing. At this time, we'd entertain any statements that you would have. Again, try to summarize or keep the written statements as short as possible. The written statements are submitted for the record and are admitted and become part of the record, so I think the important thing is to summarize the key points that you'd like to make and then perhaps even comment, if you would like, from some of the questions that were raised from the first panel. If you agree, disagree, or do you think there were perhaps some points that were not mentioned.

With that, Mr. Caldwell, would you like to begin?

STATEMENT OF JAMES H. CALDWELL, JR., PRESIDENT, ARCO SOLAR, INC., WOODLAND HILLS, CA

Mr. CALDWELL. Mr. Chairman, thank you for inviting us today for this opportunity to share our perceptions about the current and future prospects for the photovoltaics industry.

First, I'd like to say that we believe that the hearing charter is a little bit unduly pessimistic about the state of the business today. To reach a conclusion that the industry is in trouble due to lack of Government support is simply not correct. To state that we have not yet reached our optimistic projections of contribution to the energy supply is probably fair.

I think it's important to point out that all new high-technology industries are research and development intensive. They have continual ebb and flow of price reductions and plateaus, entry and departure of players, asset and personnel redeployment and success and failure of specific technologies and products, and photovoltaics is not different, and it shouldn't be.

The PV business has grown rapidly since 1978. We have grown from 6 employees to over 500 in that time period and we currently have over 400 active dealers and distributors. It's a dynamic industry with both refinement of existing technology and development of new technologies. They are both proceeding at a rapid rate.

The fact that we're now at a point where some manufacturers must decide whether the position justifies their continuation in the game is not unique to photovoltaics. The current situation should not result in a pessimistic overreaction to the future of the industry; 1984 was the best year in our history for direct domestic sales of photovoltaic modules. It was the best year in our history for foreign sales of photovoltaic modules. We are budgeting a substantial

increase for 1985. New applications abound and old applications are finding expanded markets. We really face the future with confidence, confidence in our people, confidence in our technology, confidence in our success.

The causes for concern in relationship to our international competitiveness and our domestic competitiveness with traditional fossil fuels are areas, however, where appropriate Federal incentives can play an important leveraging role in this small infant industry. Such incentives, I believe, should provide minimum call upon public funds, but maximum support to reach legitimate governmental goals.

I think we must bear in mind, as was pointed out by the previous panel, that our product is the ultimate capital good. Pay all the money now and get the energy free for the next 20 to 30 years.

Selling any capital good, especially for export in today's environment of extremely high real interest rates, soaring dollar and expectation of flat energy prices is understandably difficult, and herein lies the true source of our current business problems. Action addressing these issues is the single most effective act in support of the photovoltaics industry.

Now, turning to the specific suggestions for governmental incentives that were contained in the charter, I'd like to respond to those suggestions in turn. First, extension of the solar business tax credits. We support the extension of both the solar residential tax credits and the solar business tax credits with the enhancement of the latter to 25 percent, as contained in Senator Domenici's amendment and as passed by the Senate.

Such an incentive responds directly to the current marketplace. It enables the small manufacturer and all the distributors and dealers to benefit in this fashion. The customer determines the winner. We believe that to support our manufacturing and R&D programs, a 5-year extension of the tax credits is necessary to allow orderly planning, rather than time-constrained decisionmaking; looking over your shoulder at the date for expiration of the credits.

The current estimated revenue loss for the Domenici amendment was only \$30 million over a 4-year period, yet that bit provides invaluable support for what we believe will be a major industry expansion thereafter. Perceived or actual abusive tax avoidance schemes can be mitigated by appropriate at-risk provisions as contained in the Domenici amendment.

The second suggestion was for financing assistance, such as low-interest loans to customers for sales in the export market. Simply put, concessionary financing for export sales would be very helpful.

As was pointed out by John Day, our prime international customers tend to be the needier nations and concessionary financing is available from our competitor nations, specifically, France, Germany, and Japan.

USAID money that currently exists far too often tends to be directed toward feasibility and paper studies, with very little allocated to hardware procurement. On the other hand, our competitor nations' aid is directed almost exclusively to hardware procurement.

Certainly the U.S. Department of Energy's Photovoltaic Energy Technology Division is supporting a daylong U.S. Government/in-

dustry seminar tomorrow exploring export problems in detail—I am sure that they will share some conclusions in that area with you.

The third suggestion was for aggressive implementation of the Mavroules amendment. We certainly support the principles underlined in the Mavroules amendment, but would sound a note of caution. You can't force customers, even military ones, who take orders very well, to purchase your product against their will. The success of Mavroules will be in creating a positive atmosphere between the ultimate customer, the Department of Defense, and the PV manufacturers, their dealers and distributors.

Certainly there is no central procurement office or facility to bring the PV manufacturer and the various DOD customers together and the technology is very new and very few people really understand it—understand its application. We believe that this familiarization process is the important thing to do. Once its various potentials and uses within the DOD are known, sales from a willing supplier to a willing customer will follow.

This is our philosophy: "Try it; you'll like it," not "Buy it or else."

The fourth suggestion was completion of the SMUD project to the full planned 100 megawatts and possible initiation of other cost-shared facilities or projects. We do vigorously support the SMUD project and would support selected additional similar projects. I think it's important to point out why. The big reason to me is that SMUD is a real customer; that they are interested in purchasing equipment to generate electricity for their customers, and they have invested a substantial amount of their own money and they own and operate the facility and they are currently producing kilowatt-hours for their customers. That's the key that makes SMUD work.

The ramp-up approach to the full project is a wise one. Certainly the costs are coming down very rapidly in our industry and it's wise to avoid large financial commitments to an obsolete technology or to a high-cost technology. SMUD permits a building-block approach; creates confidence, not only success for the next stages of SMUD, but for other utilities' applications. It answers many questions and resolves numerous issues that utilities, whether municipal or investor owned, have regarding facilities interconnections, quality of power and ease of operation and maintenance.

I guess I could say that something along this line, combined with the Mavroules bill, may be a way to facilitate commercialization in the military market.

As to the fifth suggestion for Government cost sharing of production lines incorporating state of the art in photovoltaics manufacturing technology, we most strongly oppose the utilization of Federal funds for cost sharing in manufacturing production lines. It's a nonleveraging, costly application of Federal funds that virtually guarantees perpetual subsidy of obsolete technology.

If we were of the opinion that a new manufacturing facility, based on current technology, would get us to the \$2 per peak watt range, then we would build the 25-megawatt or 30-megawatt plant on our own. We do have substantial experience in actual plant construction and operation. We're not optimistic that such a scenario

is likely. We do not believe that the plans of Kyocera, the plans of Kyocera and Hoxan to build plants in the 8- to 10-megawatt range offer any cost advantage over our present facility of similar capacity.

We don't see any substantial economies of scale in increasing the plant size to 25 megawatts. Unless the cost-sharing criteria is nominal, then only larger, well-funded business entities could afford to take advantage of the matching funds available and they, including us, are, frankly, the least needy.

We're firm believers that the marketplace will yield technological differentiation. Substantial private research and development money is being spent in the belief that success will be rewarded. To even suggest that Government funds will be directed at those who do not invest on their own, or will be directed to technologies that cannot sustain it on their own sends a chill through the entire industry.

We share the observation of Mr. Hayes and Wheelwright in their book "Restoring our Competitive Edge: Competing Through Manufacturing," that "an effective manufacturing operation is not necessarily the one that promises the maximum efficiency, but one that fits the need of the business."

Federal funding must be judiciously applied to avoid doing damage, and because of its cost, must be leveraged to the greatest extent possible consistent with the legitimate goals of our industry and the Government.

We're optimistic as to the future of our industry. We disagree with the inference that the amorphous silicon and other thin film technologies will not pan out. Certainly we are investing substantial funds on that basis.

The dynamism of the industry and its technologies is alive and well. To become diverted by some need to produce hundreds of megawatts with a substantial subsidization when a more gradual method such as tax credits and SMUD projects produce a healthier, more market-responsive industry, would be a tragic mistake, a disservice both to the actual manufacturers of PV, as well as the U.S. taxpayers.

Thank you.

[The prepared statement of Mr. Caldwell follows:]

STATEMENT OF ARCO SOLAR, INC.

James H. Caldwell, Jr., President

before the

U.S. House of Representatives Committee on

Science and Technology

Subcommittee on Energy Development

and Applications

September 11, 1984

MR. CHAIRMAN, MEMBERS OF THE SUBCOMMITTEE AND THE SUBCOMMITTEE STAFF, I AM JAMES H. CALDWELL, PRESIDENT OF ARCO SOLAR, INC., A WHOLLY OWNED SUBSIDIARY OF ATLANTIC RICHFIELD COMPANY. AS A MAJOR U.S. MANUFACTURER OF PHOTOVOLTAIC PRODUCTS WITH A SUBSTANTIAL ONGOING RESEARCH AND DEVELOPMENT PROGRAM, WE WOULD LIKE TO THANK YOU FOR THIS OPPORTUNITY TO SHARE OUR PERCEPTIONS OF THE CURRENT AND FUTURE PROSPECTS OF THE U.S. PHOTOVOLTAIC INDUSTRY.

WE BELIEVE THAT THE HEARING CHARTER IS UNDULY PESSIMISTIC AS TO THE CURRENT STATE OF THE INDUSTRY. TO REACH AN OVERALL CONCLUSION THAT THE INDUSTRY IS "IN TROUBLE" DUE TO LACK OF GOVERNMENT SUPPORT IS JUST NOT CORRECT. TO STATE THAT WE HAVE NOT YET REACHED OPTIMISTIC PROJECTIONS OF MAJOR CONTRIBUTION TO U.S. ENERGY SUPPLY IS FAIR. ALL NEW HIGH TECHNOLOGY INDUSTRIES ARE RESEARCH AND DEVELOPMENT INTENSIVE, HAVE A CONTINUAL EBB AND FLOW OF PRICE REDUCTIONS AND PLATEAUS, ENTRY AND DEPARTURE OF PLAYERS, ASSET AND PERSONNEL REDEPLOYMENT, SUCCESS AND FAILURE OF SPECIFIC TECHNOLOGIES AND PRODUCTS. PHOTOVOLTAICS IS NO DIFFERENT, AND IT SHOULD NOT BE. THE P.V. BUSINESS HAS EXPANDED RAPIDLY SINCE 1978 AND INDEED ARCO SOLAR HAS GROWN FROM SIX EMPLOYEES TO OVER 500 IN THAT TIME PERIOD, AND WE HAVE APPROXIMATELY 400 ACTIVE DISTRIBUTORS AND DEALERS. IT IS A DYNAMIC INDUSTRY WITH BOTH REFINEMENT OF EXISTING TECHNOLOGIES AND DEVELOPMENT OF NEW TECHNOLOGIES PROCEEDING AT A RAPID PACE. THE FACT THAT WE ARE NOW AT A JUNCTURE WHERE SOME MANUFACTURERS MUST DECIDE WHETHER THEY WISH TO CONTINUE IN THE GAME IS NOT UNIQUE TO P.V., AND THE CURRENT SITUATION SHOULD NOT RESULT IN PESSIMISTIC OVERREACTION TO THE FUTURE OF THE INDUSTRY. INDEED WE ARE LOOKING AT 1984 AS BEING THE BEST YEAR FOR DIRECT DOMESTIC SALES OF P.V. MODULES IN OUR HISTORY. NEW APPLICATIONS ABOUND AND OLD APPLICATIONS ARE FINDING EXPANDED MARKETS.

WE FACE 1985 AND BEYOND WITH CONFIDENCE - CONFIDENCE IN OUR PEOPLE, CONFIDENCE IN OUR TECHNOLOGY, AND CONFIDENCE IN OUR EVENTUAL SUCCESS. THIS DOES NOT MEAN THAT THERE IS NO NEED FOR SOME CONCERN, FOR INDEED OUR INTERNATIONAL COMPETITIVENESS AND DOMESTIC COMPETITIVENESS WITH TRADITIONAL FOSSIL FUELS ARE PROBLEM AREAS FOR WHICH APPROPRIATE FEDERAL INCENTIVES CAN PLAY AN IMPORTANT LEVERAGING ROLE IN THIS INFANT INDUSTRY. SUCH INCENTIVES SHOULD PROVIDE MINIMUM CALL UPON PUBLIC FUNDS, BUT MAXIMUM SUPPORT TO REACH LEGITIMATE GOVERNMENTAL GOALS. OUR PRODUCT IS THE ULTIMATE CAPITAL GOOD - PAY ALL THE MONEY NOW AND GET THE ENERGY FREE FOR THE NEXT 20 TO 30 YEARS. SELLING ANY CAPITAL GOOD, ESPECIALLY FOR EXPORT IN TODAY'S ENVIRONMENT OF EXTREMELY HIGH REAL INTEREST RATES, A SOARING DOLLAR AND EXPECTATION OF FLAT ENERGY PRICES IS UNDERSTANDABLY DIFFICULT. HEREIN LIES THE TRUE SOURCE OF CURRENT BUSINESS PROBLEMS.

THE HEARING CHARTER CONTAINED FIVE SPECIFIC SUGGESTIONS FOR GOVERNMENTAL INCENTIVES DIRECTED TO THE PHOTOVOLTAICS INDUSTRY. I WOULD NOW LIKE TO RESPOND TO THESE SUGGESTIONS IN TURN.

1. [EXTENSION OF THE SOLAR BUSINESS TAX CREDITS WITH THE DOMENICI 25 PERCENT PHOTOVOLTAICS AMENDMENT AS PASSED BY THE SENATE.]

WE SUPPORT THE EXTENSION OF BOTH THE SOLAR RESIDENTIAL TAX CREDITS AND THE SOLAR BUSINESS TAX CREDITS WITH THE ENHANCEMENT OF THE LATTER TO 25% AS CONTAINED IN SENATOR DOMENICI'S AMENDMENT AND AS PASSED BY THE SENATE. SUCH AN INCENTIVE RESPONDS DIRECTLY TO THE CURRENT MARKETPLACE; IT ENABLES THE SMALL MANUFACTURER AND ALL THE DISTRIBUTORS AND DEALERS TO BENEFIT. IN THIS FASHION, THE CUSTOMER DETERMINES THE WINNER.

WE BELIEVE THAT TO SUPPORT OUR MANUFACTURING AND R&D PROGRAMS, A FIVE YEAR EXTENSION OF THE TAX CREDITS IS NECESSARY TO ALLOW ORDERLY PLANNING RATHER THAN VERY TIME CONSTRAINED DECISION MAKING; ALWAYS LOOKING OVER YOUR SHOULDER AT THE DATE FOR EXPIRATION OF THE CREDITS. THE CURRENT ESTIMATED REVENUE LOSS BY THE JOINT TAX COMMITTEE FOR THE DOMENICI AMENDMENT WAS ONLY \$30M OVER THE FOUR YEAR PERIOD, YET THAT BIT PROVIDES INVALUABLE SUPPORT FOR WHAT WE BELIEVE WILL BE A MAJOR INDUSTRY EXPANSION THEREAFTER. PERCEIVED OR ACTUAL ABUSIVE TAX AVOIDANCE SCHEMES CAN BE MITIGATED BY APPROPRIATE "AT RISK" PROVISIONS AS CONTAINED IN THE DOMENICI AMENDMENT.

2. [FINANCING ASSISTANCE, SUCH AS LOW INTEREST LOANS TO CUSTOMERS FOR SALES IN THE EXPORT MARKET.]

SIMPLY PUT, CONCESSIONARY FINANCING FOR EXPORT SALES WOULD BE VERY HELPFUL. OUR PRIME INTERNATIONAL CUSTOMERS TEND TO BE THE NEEDIER NATIONS AND CONCESSIONARY FINANCING IS AVAILABLE FROM OUR COMPETITOR NATIONS - FRANCE, GERMANY AND "JAPAN, INC.". IN ADDITION, U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT FUNDS AVAILABLE FOR RENEWABLE PROJECTS FAR TOO OFTEN TEND TO BE DIRECTED TO FEASIBILITY AND PAPER STUDIES WITH VERY LITTLE ALLOCATED TO HARDWARE. ON THE OTHER HAND, OUR COMPETITOR NATIONS' AID IS DIRECTED ALMOST EXCLUSIVELY TO HARDWARE PROCUREMENT. THE U.S. DEPARTMENT OF ENERGY'S PHOTOVOLTAIC ENERGY TECHNOLOGY DIVISION, WILL BE SPONSORING A DAY LONG U.S. GOVERNMENT/INDUSTRY SEMINAR TOMORROW EXPLORING EXPORT PROBLEMS IN DETAIL, AND I AM SURE THEY WILL HAVE CONCLUSIONS AND RECOMMENDATIONS TO SHARE WITH YOU.

3. [AGGRESSIVE IMPLEMENTATION OF THE 1983 MAVROULES AMENDMENT TO THE MILITARY CONSTRUCTION AUTHORIZATION ACT REQUIRING THE PURCHASE OF SOLAR EQUIPMENT BY THE DEPARTMENT OF DEFENSE WHEREVER LIFE-CYCLE COST EFFECTIVE.]

WE SUPPORT THE PRINCIPLES UNDERLYING THE MAVROULES AMENDMENT TO THE MILITARY CONSTRUCTION AUTHORIZATION ACT, BUT WOULD SOUND A NOTE OF CAUTION. YOU CANNOT FORCE CUSTOMERS, EVEN MILITARY ONES, TO PURCHASE YOUR PRODUCT AGAINST THEIR WILL. IN SOME WAYS, IT IS AKIN TO LEGISLATING MORALITY. THE SUCCESS OF MAVROULES WILL BE IN CREATING A POSITIVE ATMOSPHERE BETWEEN THE ULTIMATE CUSTOMER, THE DEPARTMENT OF DEFENSE (DOD), AND THE P.V. MANUFACTURERS, THEIR DEALERS AND DISTRIBUTORS. THE RECENT SOLAR ENERGY INDUSTRY ASSOCIATION SPONSORED DOD PRESENTATION HAS SUBSTANTIATED, THAT THERE IS NO CENTRAL PROCUREMENT OFFICE OR FACILITY TO BRING TOGETHER THE P.V. MANUFACTURER AND THE VARIOUS DOD CUSTOMERS. WE BELIEVE THAT ONCE THE CUSTOMER HAS AN OPPORTUNITY FOR HANDS-ON FAMILIARIZATION WITH P.V. AND ITS VARIOUS POTENTIAL USES WITH THE DOD, THAT SALES FROM A WILLING SUPPLIER TO A WILLING CUSTOMER WILL FOLLOW. SUCH A DOD FAMILIARIZATION PROGRAM SHOULD BE THE WAY TO AGGRESSIVELY IMPLEMENT MAVROULES. THIS IS OUR PHILOSOPHY OF "TRY IT, YOU'LL LIKE IT", RATHER THAN "BUY IT, OR ELSE".

4. [COMPLETION OF THE SMUD PROJECT TO THE FULL PLANNED 100 MW, AND POSSIBLE INITIATION OF OTHER COST-SHARED FACILITIES OR PROJECTS.]

WE VIGOROUSLY SUPPORT THE SMUD PROJECT, AND WOULD SUPPORT SELECTED ADDITIONAL SIMILAR PROJECTS. SMUD IS A REAL CUSTOMER AND NOT A PUBLIC RELATIONS PROJECT. SMUD INVESTED A SUBSTANTIAL AMOUNT OF ITS MONEY, AND OWNS AND OPERATES THE FACILITY PRODUCING KILOWATT HOURS OF ELECTRICITY FOR ITS CUSTOMERS.

THE RAMP-UP APPROACH TO THE FULL PROJECT IS A WISE ONE SINCE IT UTILIZES CURRENT STATE OF THE ART PHOTOVOLTAIC TECHNOLOGIES, BUT AVOIDS LARGE FINANCIAL COMMITMENTS TO AN OBSOLETE ONE. IT PERMITS A BUILDING BLOCK APPROACH CREATING CONFIDENCE, NOT ONLY IN SUCCESS FOR THE NEXT STAGES OF SMUD BUT FOR OTHER UTILITIES' APPLICATIONS. IT ANSWERS, IN AN ORDERLY FASHION, MANY QUESTIONS AND RESOLVES NUMEROUS ISSUES THAT UTILITIES, WHETHER MUNICIPAL OR INVESTOR OWNED, HAVE REGARDING FACILITIES INTERCONNECTIONS, QUALITY OF POWER, AND EASE OF OPERATION AND MAINTENANCE. PERHAPS THIS FORM OF ASSISTANCE COULD BE COMBINED WITH THE MAVROULES BILL TO FACILITATE COMMERCIALIZATION IN THE MILITARY MARKET.

5. [GOVERNMENT COST-SHARING ON PRODUCTION LINES INCORPORATING THE STATE-OF-THE-ART IN PHOTOVOLTAICS MANUFACTURING TECHNOLOGY.]

WE STRONGLY OPPOSE UTILIZATION OF FEDERAL FUNDS FOR COST SHARING ON MANUFACTURING PRODUCTION LINES. IT IS A NONLEVERAGING, COSTLY APPLICATION OF FEDERAL FUNDS THAT VIRTUALLY GUARANTEES PERPETUAL GOVERNMENT SUBSIDY OF OBSOLETE TECHNOLOGY. IF WE WERE OF THE OPINION THAT A NEW MANUFACTURING FACILITY BASED ON CURRENT TECHNOLOGY WOULD GET US TO \$2.00 PER PEAK WATT, THEN WE WOULD BUILD SUCH A 25 MEGAWATT PLANT ON OUR OWN. HAVING SUBSTANTIAL EXPERIENCE IN ACTUAL PLANT CONSTRUCTION AND OPERATION, WE ARE NOT OPTIMISTIC THAT SUCH A SCENARIO IS LIKELY. WE DO NOT BELIEVE THAT THE ANNOUNCED PLANS OF KYOCERA AND HOXAN TO BUILD PLANTS IN THE 8-10 MW RANGE OFFER ANY COST ADVANTAGE OVER OUR PRESENT FACILITY OF SIMILAR CAPACITY. WE ALSO DO NOT SEE ANY SUBSTANTIAL ECONOMICS OF SCALE IN INCREASING THE PLANT SIZE TO 25 MW.

IN ADDITION, UNLESS THE COST SHARING CRITERIA WERE NOMINAL, e.g., 5-20%, THEN ONLY LARGER WELL-FUNDED BUSINESS ENTITIES COULD AFFORD TO TAKE ADVANTAGE OF THE MATCHING FUNDS AVAILABLE. THEY, INCLUDING US, ARE FRANKLY THE LEAST NEEDED.

- 6 -

WE ARE FIRM BELIEVERS THAT THE MARKETPLACE WILL YIELD TECHNOLOGY DIFFERENCIATION. SUBSTANTIAL PRIVATE RESEARCH AND DEVELOPMENT MONEY IS BEING SPENT IN THE BELIEF THAT SUCCESS WILL BE REWARDED. TO EVEN SUGGEST THAT GOVERNMENT FUNDS WILL BE DIRECTED TO THOSE WHO DO NOT INVEST ON THEIR OWN, SENDS A CHILL THROUGH THE ENTIRE INDUSTRY.

INDEED WE SHARE THE RECENT OBSERVATION BY MESSRS. HAYES AND WHEELWRIGHT IN THEIR BOOK RESTORING OUR COMPETITIVE EDGE: COMPETING THROUGH MANUFACTURING, THAT "AN EFFECTIVE MANUFACTURING OPERATION IS NOT NECESSARILY THE ONE THAT PROMISES THE MAXIMUM EFFICIENCY... BUT ONE THAT FITS THE NEEDS OF THE BUSINESS".

MARKET PULL UTILIZING VAST SUMS OF FEDERAL MONEY TO BUILD LARGE PLANTS WHOSE OBSOLESCENCE IS VIRTUALLY GUARANTEED, MAKES LITTLE SENSE WHEN CONTINUATION OF THE TAX CREDITS IS BEING VIGOROUSLY CHALLENGED.

FEDERAL FUNDINGS MUST BE JUDICIOUSLY APPLIED TO AVOID DOING DAMAGE, AND BECAUSE OF THE COST, MUST BE LEVERAGED TO THE GREATEST EXTENT POSSIBLE CONSISTENT WITH THE LEGITIMATE GOALS OF OUR INDUSTRY AND THE GOVERNMENT.

WE ARE OPTIMISTIC AS TO THE FUTURE OF OUR INDUSTRY. WE DISAGREE WITH THE INFERENCE THAT AMORPHOUS SILICON AND OTHER THIN FILM TECHNOLOGIES WILL NOT PAN OUT. THE DYNAMISM OF OUR INDUSTRY AND ITS TECHNOLOGIES IS ALIVE AND WELL. TO BECOME DIVERTED BY SOME SEEMING NEED TO PRODUCE HUNDREDS OF MEGAWATTS WITH A SUBSTANTIAL SUBSIDIZATION WHEN A MORE GRADUAL METHOD SUCH AS TAX CREDITS AND SMUD PROJECTS PRODUCE A HEALTHIER, MORE MARKET RESPONSIVE INDUSTRY, WOULD BE A TRAGIC MISTAKE; A DISSERVICE BOTH TO THE ACTUAL MANUFACTURERS OF P.V. AS WELL AS THE U.S. TAXPAYERS.

AGAIN, WE AT ARCO SOLAR WOULD LIKE TO THANK YOU FOR THE OPPORTUNITY OF APPEARING BEFORE THE SUBCOMMITTEE TODAY, AND I WOULD BE PLEASED TO ANSWER ANY QUESTIONS YOU MIGHT HAVE.

Mr. McCURDY. Thank you, Mr. Caldwell.
Mr. Corsi—is that—am I pronouncing that right?

**STATEMENT OF JOHN CORSI, PRESIDENT, SOLAREX CORP.,
ROCKVILLE, MD**

Mr. CORSI. That's the correct pronunciation, Mr. Chairman. Photovoltaics, the direct conversion of sunlight into electricity, is on its way to becoming one of the most important forms of renewable energy. Anyone who has more than a nodding acquaintance with it is aware of the unique qualities that make it an extremely desirable source of electricity.

This, along with significant cost reductions in the last decade, has established it as a cost-effective power source for many applications in regions of the world. However, we've barely scratched the surface. An order of magnitude reduction in costs will be required to realize its full potential.

To date, most of the commercial progress in photovoltaics has been made using hand-me-down techniques from the electronics industry. It is clear that the required reductions in cost will never be achieved with technology borrowed from the semiconductor industry. The PV industry must continue, as it has been doing, to develop materials and technology that are more cost effective for photovoltaic applications.

The problem is to continue these developments in the face of current market demand, which is considerably less than the available supply. This, along with strong competitive pressure on the part of companies to establish market share for the future, results in an environment that produces losses rather than profits for most, if not all, of the companies competing in the field.

Because of the typical U.S. business emphasis on short-term profitability, many U.S. companies have withdrawn from the field entirely or severely restricted their investments only to be replaced by foreign competition, particularly the Japanese. Since 1973, both the Federal Government and private industry has recognized the potential of photovoltaics as evidenced by the funds expended, \$700 million from the Government and \$850 million from the private sector.

In spite of these investments, U.S. market share has eroded from 95 percent in 1978 to 55 percent today. The drop can be attributed to several factors. Many countries have erected trade barriers and adopted policies to protect their domestic markets. There are strong nationalistic interests in the energy field. As PV becomes more important, it is receiving greater Government attention. For example, Australia has a tariff of 35 percent. Brazil has strict import licensing procedures which protect their local manufacturers.

Second, very aggressive support of export activities on the part of European and Japanese Governments. The Japanese in particular see photovoltaics as a sunrise industry, worthy of major Government backing through companies such as Fuji, Sanyo, Sharp and Kyocera. It is the policy of these Governments to focus support on a few key companies. The selected companies become very effective worldwide competitors because of this concentration of Government support, as opposed to the U.S. policy, which Solarex endorses, of making support available to many companies.

Third, the change in currency exchange values. Since late 1982, the value of the U.S. dollar, as we all know, has increased dramati-

cally against all foreign currencies. Making products produced in these countries, even though they may be less efficient processes, quite price-competitive.

Now, it is Solorex's view that the most effective way for the U.S. Government to assist our industry to achieve and maintain a significant share of what can be a rapidly growing \$1 billion market by 1990 is through programs that help to develop the long-term markets. Further, history has shown that to be successful in international commerce, U.S. manufacturing requires the experience and example of a functioning domestic market. Failure to create such a viable market will result in further erosion of world market share for U.S. manufacturers leading to an ironic predicament, which is the import of products based on technologies that were initially researched and developed in the United States. An existing trade imbalance in excess of \$60 billion attests to the seriousness of this problem.

It is our belief that the most effective way of developing our domestic market is through the use of tax credits. The existing business energy tax credits originated in 1979 and 1980, as the Congress sought to encourage the development of alternative energy resources. Unfortunately, they have been of little value to the industry. The current 15-percent credit does not provide an attractive return on investment to those purchasing today's PV systems which sell for approximately \$10-12 per installed peak watt. To provide investors with a required 15- to 20-percent return, a 15-percent Federal credit, in addition to all the other credits available, would necessitate an installed systems price in the range of \$5-6 a watt. The industry cannot achieve profitability at this price level until late in the decade.

At the price levels anticipated over the next several years, we estimate energy tax credits in the range of 25 to 30-percent are necessary for the program to be effective. The 30 percent credit would be particularly attractive in that it would allow consumers in States which do not have additional State credits to also benefit from the Federal credit.

Solorex advocates an extension of the Federal energy tax credits in form similar to that passed by the Senate in amendments to the 1984 tax bill. Specifically, this would have extended the credits for 4 years; the first 2 years at 25 percent and the last 2 at 20 percent.

It was estimated by the Joint Committee on Taxation that the revenue loss from this extension would have been less than \$10 million a year. This is a truly insignificant sum in the face of over \$1½ billion already invested in this industry and compared to tax grants for conventional energy sources, which has been estimated by the Joint Committee to be \$3.88 billion in 1983 alone.

The other major change that we recommend, in addition to extending and enlarging the tax credits, is to allow our electric utility companies to use them. These utilities are key future customers for photovoltaics. It is estimated that they must place 121 billion watts of new or replacement-generated capacity in place by the end of the decade.

The plan to use nuclear power to generate a significant portion of this is in jeopardy. Nearly 12 and a half gigawatts of this nuclear capacity has been indefinitely deferred or outright cancelled.

There are currently 40 nuclear plants under construction in 20 States. Delays and escalating construction costs which have been widely publicized can drive the cost of installing this capacity to in excess of \$5 a watt. Further, it has been estimated that at least one-half of these plants will never reach commercial operation.

Because of the relative insensitivity to economics of scale, photovoltaic arrays can be installed in small increments on either a centralized or decentralized basis. Systems can be built in capacity increments with leadtimes that more closely match the growth of demand. Further, the technology is high modular so that large systems can be constructed by aggregating numbers of small systems. At the net right—at the right net price to the utilities, photovoltaic power can relieve, at least in some small part, some of the problems they face.

A strong domestic market provides the springboard to an effective worldwide competitive position. We cannot ignore international markets. Bringing electric power to 3 billion people in the world who now live without it is the long-range promise of the photovoltaics industry. International markets currently represent more than 50 percent of the total. This will grow as the problems of financing installations and developing support infrastructures in lesser developed countries are addressed.

Solarex believes that the best near-term help in addressing these can come from existing agencies, in particular, the U.S. Agency for International Development.

The primary goal of USAID is to carry out assistance programs directed toward meeting basic human needs and improving economic growth in LDC's. Energy is a priority area for assistance with concentration on reducing the LDC's dependence on imported energy, particularly oil and gas.

USAID is a decentralized operation in which energy and energy-related programs are dispersed. The functional bureaus provide agencywide support while the geographic bureaus conduct projects in particular world geographic regions, but in general, the majority of USAID's projects involve country-specific projects which originate in the overseas host country missions.

We recognize that the primary mission of the Agency for International Development is to assist in satisfying basic human needs and improving economic growth in developing countries, and not that of developing markets for U.S. products. Nevertheless, Solarex believes that our efforts to develop photovoltaic markets in lesser-developed countries are consistent with their objectives.

Photovoltaic power is the clean and simple-to-use energy source which has been proven cost-effective in many different applications, such as telecommunications, remote health facilities and water-pumping; thus providing services without continued dependence on imported energy. Our technology aims at one of the basic obstacles of LDC development. We believe that there is room for more cooperation and coordination between USAID and the PV industry. However, the size and complexity of the USAID organization, along with its fragmented and decentralized decisionmaking process, is a basic obstacle to PV industry use of USAID resources.

To improve the effectivity of USAID programs, we suggest the following: One, alter the present procurement practices which are

a source of frustration to those of us in the industry committed to long-term market development. After spending time and resources in educating eligible foreign agencies in the uses and benefits of PV, we must compete for the approved project with other companies through a public tender. It is generally a cutthroat effort in which the companies with the lowest internal resources—for example, those without the technical and sales resources to provide educational and market development help—can provide the lowest price, but not necessarily the best value.

Mechanisms to ensure fair prices and practices are necessary, but should not work to the detriment of those who invest resources to develop new markets and users. One possible solution would be to establish a system similar to the GSA pre-approved supply schedule and price list. The agencies eligible for USAID funds would then be able to purchase PV equipment from the company of their choice at pre-approved prices.

Second, set up a pool of funds specifically earmarked for photovoltaic installations. The countries that need our products the most are very often the ones least able to afford them. The availability of funds earmarked for PV will help USAID achieve its objectives and provides further impetus for a strong U.S. photovoltaic industry.

Third, set up a clearly defined internal USAID communication channel to establish and maintain a high level of awareness and information at the country mission level regarding PV uses and capabilities. This channel would then be available to the PV industry to deliver product, application and technical information to the country missions.

In summary, I would like to reiterate Solarex's strong conviction that market development assistance will yield the most benefits to the photovoltaic industry, both domestically and internationally. If the Government helps create the markets that drive the developments, the industry will take care of itself. In this regard, I agree very, very much with what John Day said previously.

I also want to reiterate the importance of assistance from the government. Without it, the photovoltaics industry situation is critical. The United States stands to lose another emerging high-technology industry to foreign competition with the consequent loss of jobs and energy security. We cannot afford to let that happen.

Thank you.

[The prepared statement of Mr. Corsi follows:]

STATEMENT OF JOHN CORSI

PRESIDENT

SOLAREX CORPORATION

BEFORE THE U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

SEPTEMBER 11, 1984

STATUS OF THE INDUSTRY

Photovoltaics, the direct conversion of sunlight into electricity, is on its way to becoming one of the most important forms of renewable energy. Anyone who has more than a nodding acquaintance with it is aware of the unique qualities that make it an extremely desirable source of electricity. This, along with significant cost reductions in the last decade, has established it as a cost effective power source for many applications in most regions of the world ... however, we've barely scratched the surface of its enormous potential. Another order of magnitude reduction in costs will be required to realize this full potential.

To date most of the commercial progress in photovoltaics has been made using "hand-me-down" techniques from the electronics industry (i.e., Cz silicon wafers). It is clear that the required reductions in cost will never be achieved with technology borrowed from the semiconductor industry. The industry must continue, as it has been doing, to develop materials and technology that are more cost effective for photovoltaic application.

The problem is to continue to fund these developments in the face of current market demand which is considerably less than the available supply. This, along with strong competitive pressure on the part of companies to establish market share for the

future, results in an environment that produces losses rather than profits for most, if not all of the companies competing in the field.

Because of the typical U.S. business emphasis on short term profitability, many U.S. companies have withdrawn from the field entirely or severely restricted their investments only to be replaced by foreign competition, particularly the Japanese. Since 1973, both the federal government and private industry has recognized the potential of photovoltaics as evidenced by the funds expended - \$700 million from the government and \$850 million from the private sector. In spite of these investments U.S. market share has eroded from 95% in 1978 to 55% today.

The drop can be attributed to several factors:

- Many countries have erected trade barriers and adopted policies to protect their domestic markets. There are strong nationalistic interests in the energy field. As PV becomes more important, it is receiving greater government attention. For example, Australia has a tariff of 35%; Brazil has a strict import licensing procedure which protects their local manufacturers.
- Very aggressive support of export activities on the part of European and Japanese governments. The

Japanese, in particular, see photovoltaics as a "sunrise industry" worthy of major government backing through companies such as Fuji Electric, Sanyo, Sharp and Kyocera. It is the policy of these governments to focus support on a few key companies. The selected companies become very effective worldwide competitors because of this concentration of government support (as opposed to the U.S. policy, which Solarex endorses, of making support available to many companies).

- Change in currency exchange rates. Since late 1982, the value of the U.S. dollar has increased against the French franc, the German mark, and the Japanese yen -- allowing these countries' products to be price competitive even with less efficient processes.

It is Solarex's view that the most effective way for the U.S. government to assist our industry to achieve and maintain a significant share of what can be a rapidly growing \$1 billion market by 1990, is through programs that help to develop long term markets.

Further, history has shown that to be successful in international commerce, U.S. manufacturing requires the experience and example of a functioning domestic market. Failure to create such a viable market will result in further erosion of world

market share for U.S. manufacturers leading to the ironic predicament faced by many U.S. manufacturers - imports of manufactured products based on technologies that were initially researched and developed in the U.S. An existing trade imbalance in excess of \$60 billion attests to the seriousness of this problem.

TAX CREDITS TO SPUR THE U.S. MARKET

It is our belief that the most effective way of developing our domestic markets is through the use of tax credits. The existing business energy tax credits originated in 1979 and 1980 as the Congress sought to encourage development of alternate energy resources. Unfortunately, they have been of little value to the industry. The current 15% credit does not provide an attractive return on investment to those purchasing today's PV systems which sell for approximately \$10 to \$12 per installed peak watt. To provide investors with the required 15% to 20% return, a 15% federal energy credit (in addition to all other credits available) would necessitate an installed systems price in the range of \$5 to \$6/watt. The industry cannot achieve profitability at this price level until late in this decade.

At the price levels anticipated over the next several years, we estimate energy tax credits in the range of 25% to 30% are necessary for the program to be effective. The 30% credit would

be particularly attractive in that it would allow consumers in states which do not have additional state credits to also benefit from the federal credit. Solarex advocates an extension of the federal energy tax credits in forms similar to that passed by the Senate in amendments to the 1984 tax bill. Specifically this would have extended the credits for four years; the first two years at 25% and the last two at 20%.

It is estimated that the revenue loss from this extension would be less than \$10MM/year. This is a truly insignificant sum in the face of over \$2 billion dollars already invested in this industry and compared to tax grants for conventional energy sources which has been estimated by the Joint Committee on Taxation to be \$3.88 billion in 1983 alone.

AVAILABILITY OF CREDITS TO OUR ELECTRIC UTILITIES

The other major change that we recommend, in addition to extending and enlarging the tax credits, is to allow our electric utility companies to use them. (Under current legislation they cannot.) These utilities are key future customers for photovoltaics. It is estimated that they must put in place 121 gigawatts (121,000,000,000 watts) of new or replacement generating capacity by the end of the decade. The plan to use nuclear power to generate a significant portion of this is in jeopardy. Nearly 12.5 gigawatts of this nuclear based capacity has been

indefinitely deferred or outright cancelled. There are currently forty nuclear plants under construction in twenty states. Delays and escalating construction costs, which have been widely publicized, can drive the cost of installing this capacity to in excess of \$5/watt. Further it has been estimated by one prominent energy analyst, Charles Komanoff, that at least one half of these plants will never reach commercial operation.

Because of their relative insensitivity to economies of scale, photovoltaic arrays can be installed in small increments on either a centralized or decentralized basis. Systems can be built in capacity increments with lead times that more closely match the growth of demand. Further the technology is highly modular so that large systems can be constructed by aggregating numbers of small systems. At the right net price to the utilities photovoltaic power can relieve, at least in part, some of the problems they face.

In summary we believe that extension and enhancement of energy tax credits along with utility access to them will:

- Contribute to the solution of the serious problems faced by our electric utilities in economically providing the additional generating capacity that will be required for the remainder of this century.

- Provide the impetus for continuing investment by the private sector in the photovoltaic industry which can be a significant factor in the U.S. economy in the years to come.

EXPORT AID

A strong domestic market provides the springboard to an effective worldwide competitive position. We cannot ignore international markets. Bringing electrical power to the three billion people in the world who now live without it is the long range promise of the photovoltaics industry. International markets currently represent more than 50% of the total. This will grow as the problems of financing installations and developing support infrastructures in lesser developed countries (LDC's) are addressed.

Solarex believes that the best near term help in addressing these can come from existing agencies, in particular the U.S. Agency for International Development (USAID).

The primary goal of the USAID is to carry out assistance programs directed towards meeting basic human needs and improving economic growth in LDC's. Energy is a priority area for assistance with concentration on reducing the LDC's dependence on imported energy, principally oil and gas.

USAID is a decentralized operation in which energy and energy-related programs are dispersed. The functional bureaus provide agency wide support while the geographic bureaus conduct projects in particular world geographic regions, but in general, the majority of USAID's projects involve country-specific projects which originate in the overseas host country missions.

Within the Science and Technology Bureau, the Office of Energy is responsible for conducting all USAID centrally operated energy activities, including field demonstration projects, technical assistance and training. The Office of Energy's primary thrust is to field test available technologies to determine whether they are appropriate for the LDC's, given the economic, social and institutional situation of these countries.

Also within the Bureau for Science and Technology, the Offices of Food and Agriculture as well as Health and Population fund projects in developing countries that require power for remote applications. In many instances, such as irrigation, water pumping and refrigeration these power needs could be supplied by PV systems. However, staff and program managers in these offices are not fully aware of the benefits, performance, applications and economics of PV, nor are they familiar with PV manufacturers and suppliers.

We recognize that the primary mission of the Agency for International Development is to assist in satisfying basic human needs and improving economic growth in developing countries and not that of developing markets for U.S. products. Nevertheless, Solarex believes that our efforts to develop photovoltaic markets in lesser developed countries are consistent with their objectives.

Photovoltaic power is a clean and simple-to-use energy source which has been proven cost effective in many different applications such as telecommunications, remote health facilities and water pumping; thus providing services without continued dependence on imported energy. Our technology aims at one of the basic obstacles of LDC development. We believe that there is room for more cooperation and coordination between USAID and the PV industry. However, the size and complexity of the USAID organization along with its fragmented and decentralized decision making process is a basic obstacle to the PV industry use of USAID resources.

To improve the effectivity of USAID programs, we suggest the following:

- Alter the present procurement practices which are a source of frustration to those of us in the industry committed to long term market development. After

spending time and resources in educating eligible foreign agencies in the uses and benefits of PV, we must compete for the approved project with other companies through a public tender. It is generally a "cut throat" effort in which the companies with the lowest internal costs (i.e., those without the technical and sales resources to provide educational and market development help) can provide the lowest price, but not necessarily the best value. Mechanisms to ensure fair prices and practices are necessary, but should not work to the detriment of those who invest resources to develop new markets and users. One possible solution would be to establish a system similar to the GSA pre-approved supply schedule and price list. The agencies eligible for USAID funds would then be able to purchase PV equipment from the company of their choice at pre-approved prices.

- Set up a pool of funds specifically earmarked for photovoltaic installations. The countries that need our products the most are very often the ones least able to afford them. The availability of funds earmarked for PV will help USAID achieve its objectives and provides further impetus for a strong U.S. photovoltaic market.

- Set up a clearly defined, internal USAID communication channel to establish and maintain a high level of awareness and information at the country mission level regarding PV uses and capabilities. This channel would then be available to the PV industry to deliver product, application and technical information to the country missions.

In summary, I would like to reiterate Solarex' strong conviction that market development assistance will yield the most benefits to the photovoltaic industry both domestically and internationally. If the government helps to create the markets that drive developments, the industry will take care of itself. I also want to reiterate the importance of assistance from the government. Without it, the photovoltaic industry's situation is critical; the U.S. stands to lose another emerging high technology industry to foreign competition, with the consequent loss of jobs and energy security. We cannot afford to let that happen.

MR. JOHN CORSI is President and Chief Executive Officer of Solarex Corporation, a leader in production of photovoltaic cells, panels and systems, headquartered in Rockville, Maryland. Mr. Corsi has been with Solarex since January 1, 1983 and prior to that he served as a director since April 30, 1982.

Before joining Solarex he was a Group Vice President with Analog Devices, Inc. of Norwood, Massachusetts, and was with them for ten years.

He holds a B.S. in Electrical Engineering from the University of Massachusetts and a M.E.A. from Northeastern University. He is a former member of the Deans Advisory Council and holder of the Alumnus Award from the University of Massachusetts.

Mr. McCurdy. Thank you, Mr. Corsi.
Mr. Lampert.

STATEMENT OF ERNEST LAMPERT, PRESIDENT, UNITED ENERGY CORP., FOSTER CITY, CA

Mr. LAMPERT. Mr. Chairman, my name is Ernest Lampert. I am the president of United Energy Corp. We're a private family-owned company and we used our own private funds to start the company back in 1978, and by 1979, we had started manufacturing and selling photovoltaic modules.

The company studied the entire renewable energy picture: How it affects the world; how it affects America. We recognize that the dwindling resources that we have in our fossil fuels and our other energy resources and the pollution that sometimes is created as the use of these fuels is something that we had to address; that we had to develop technology and businesses and manufacturing companies to provide this equipment to America.

We realize that the fossil fuels and the nuclear energy and coal and all the other energies that has helped America get to the point we are which fueled our American Revolution when we used wood—and we fueled our Industrial Revolution when oil and some of the other coals and other energy resources helped us be able to power such an energy-demanding society.

America is dependent on energy. Our lifestyles and all of our particular businesses, our Government functions and everything depends on energy. Where we get that energy from now, where we get it from in the future depends on what we do here.

United Energy recognized that of all the renewable resources, photovoltaic technology appeared to be the best one to specialize in. Although United Energy Corp. does specialize in biomass energy, the production of alcohol and proteins, the solar thermal industry and also wind and hydro we support. And we have active research going on in all those areas.

The best way that I can proceed with testimony here today is probably to explain how we got here. United Energy, having started in Honolulu, HI, was able to learn about renewable resources and then we traveled here to Washington in 1978 and in 1979 where we met with DOE officials; we learned about the DOE photovoltaic program; we were able to take advantage of the different research technologies that DOE programs had funded in the past and between 1978 and now, our company has been able to grow from just buying solar cells from other manufacturers and placing them into modules in 1979; by 1981, we were producing our own silicon—one-Sun solar cells—and presently we are now able to produce 100 times silicon concentrator cells, which is the most advanced type cell we believe currently manufactured.

Without the DOE programs of the past and the Government support of these programs, we would not have been able to accomplish this at all. We probably couldn't even still be in the business without these programs.

It's very important to recognize and to give praise to the various programs of the past that were carried out by Jet Propulsion Laboratories where we were able to develop—I mean, get experience and help from them on one-Sun flat-plate modules and now Sandia Laboratories, which has helped us with concentrator modules. I don't want to exclude Surry, which has done a great job in helping disseminate the different technologies and doing work in advanced

research at Surry and I know there's many more that I can't take the time to describe today.

The importance of developing photovoltaics—why is it important? Is the help from the Federal Government needed now or should it be maybe looked at into the future when there are so many deserving programs which Congress has to look at each year? We believe that photovoltaics is a technology that needs to be developed now.

As we look into the future, we realize that by 1990, we look at our energy needs in America; by 1995, by the year 2000, and we try to equate all the other energy resources we have, will photovoltaics provide a significant amount of the energy production required by the year 2000? Some people say 2 percent. I always like to say 5 to 10 percent aggressively. Are we a threat to any other types of resources? The answer to that is no.

As America continues to use its nonrenewable resources, the resources that helped us get this far, the resources that will help us get into the year 2000, we have to take and supplement those resources as we're using them with renewable resources, of which photovoltaics is the prize.

How will we be able to use those resources and collect them, and how will we be able to manufacture the equipment and where will it go? If we expand our thinking a little bit, we can easily see that rooftops are certainly a good place to collect solar energy. They should be used for more than just keeping the rain off, and certainly, the rooftops provide decentralized security to our Nation.

If there was ever a national disaster where energy shortages or stoppages or just the lack of the resource occurred, it would be photovoltaic technology on the rooftops that would keep our refrigerators going, keep us lights at night, as well as to probably phone our neighbors and phone our bosses and be able to also get to work. We do perceive that photovoltaics in the future will provide this country with the rooftop electric generation for factories, for our schools, for our businesses, for our Government buildings and especially our military facilities.

Photovoltaics will provide the energy to help supplement these other resources as they're dwindling. We feel that the manufacturing companies that will be needed to manufacture the amount of megawatts of photovoltaic equipment for rooftop applications will provide many new jobs into the American sector that are going to be needed into the future. Also, we support this because we feel that America needs not only its central receiver-type electric generation where we're tied to a fragile grid with central receivers or central generating plants to a combination of decentralized and centralized generating. In other words, where we can have each house that has a photovoltaic system on it; each factory, school, public building, tied into the utility grid along with the central utility plants, will provide America with a more blackout-proof type energy system. This has got to be important because I fear to say that we could all recognize what would happen if America was one week without energy, just one week. If you can project your thinking, you can see what would happen. We couldn't even come to meetings like this for that week.

So it is very important that we recognize that photovoltaics is that type of technology. It is a high technology. It is one of the technologies we want to keep in America; we want to develop in America. It is one of the technologies that will provide us the ability to collect free incoming energy which comes from an inexhaustible resource, the sun. It comes to us pollution-free. As you mentioned earlier, it has no moving parts. It is silent; it is beautiful and basically it will provide us that particular electric plug to an inexhaustible resource.

We examined the use of the tax credits that we've used in the past with United Energy Corp. We've been asked questions why we've lobbied for the extension of these credits. Is there any real benefit to the country from them? Is there a big drain on the Treasury which people have tried in reports to say that there is? I have—I have done some soul-searching on that and I looked at our bills—I looked at the money that we have taken in from the Government programs from tax credits, and I looked at our payables, where the money went.

I realized that we really do not drain the Treasury with the use of tax credits to stimulate the photovoltaic industry as much as perhaps has been reported in the past. The money that we have spent has gone to major American corporations, some of the largest that we have in the land, for parts and materials that they supply to various parts of our equipment. We provided—our money goes to pay the payrolls, which is very diverse. We have nonskilled immigrant labor; we have semiskilled labor; we have skilled labor; we have plumbers, electricians, carpenters. We have just about every segment of the trades employed that there is. We provide a lot of money to attorneys to provide us legal assistance; the bankers get a good share of it. We have found that all the material suppliers that we have paid this money to also have a lot of employees. So I believe that there is more than a trickle-down effect to the Treasury, as has been indicated earlier.

I think there is a stream of money going back to the Treasury from the use of tax credits that are used by companies like mine to provide these jobs which are very important, to buy the materials from other companies which helps them, and when we take and interact—if we put all that money back into our society and it rolls through the society, it creates all that new tax base from those jobs that were created as a result of those tax credits which helps bring money back to our Treasury.

So, technology, I don't believe the cost to the Government over the period of time into the future will be very much, as related to the long-term return of the money to our tax system. Photovoltaics, because they collect free incoming energy—we don't have to pay for that energy anymore; it is only an equipment problem. All we have to do is collect the energy and spin a meter with it and we earn income. That income is revenue. We have a tax system which taxes revenue in this country. The taxation on the revenue from collecting sunlight will bring great financial income in the years ahead to replace all the dollars it takes to stimulate and get our American photovoltaic industry going today.

We have our energy capital in America locked up with our reserves underground in fossil fuels. We certainly have had to use

those fossil fuels and that energy capital to get this far and we will need to continue to use them into the future.

These resources are very important and renewable resources will not be able to provide a significant amount of energy by the year 2000 to totally replace any of these resources, but as these resources, as I mentioned earlier, dwindle, we will be able to at least supplement the resources with renewable resources.

Where can we get to by 1985, 1990 and the year 2000? Our company—which is what I'd like to do at this time, show some photographs here of some of the work we have been doing so you can have an idea of what we're attempting—our company grew from five people and a few thousand square feet to—right now, we have over 135,000 square feet of R&D, manufacturing and office space, with over 700 employees.

The—our early years, we addressed the remote markets by going around the world and selling photovoltaic modules for remote applications, as has been mentioned by other manufacturers here. We realized, however, that the industry wasn't really going anywhere, as we perceived it, to—in that particular market, because of the problems in selling the equipment to foreign countries inasmuch as they have import duties that seem to be a problem to us and other restrictions which help us—which hinder us in marketing the equipment abroad.

So we at United Energy decided that we better first solve America's energy problems first, and so, therefore, we redirected our efforts towards what we call utility scale applications of photovoltaics, and also what we call our integrated life system at United Energy, where we have integrated another couple of the technologies of renewable resources into a solar energy farm.

At this time, I'd like to show you what a solar energy farm is and, if I may, I'd stand up and show it around.

Mr. McCURDY. Certainly.

[Photograph.]

Mr. LAMPERT. This is a—this is a overhead shot of Borrego Springs, CA. This is about an hour-and-45-minute drive east of San Diego, CA, and it sits on 300 acres, even though we've only used about 60 acres of the project so far. In the photograph, we show here these little white spots are automobiles and—so you can get an idea that these round circular ponds that we have are over an acre in size or 250 feet in diameter and is what we believe is the direction for central power utility scale type electric generation as we develop the industry, meaning the solar farms can be integrated into a utility and, therefore, provide what we call central receiver power, along with, of course—I'd never want to forget the decentralized power that we can put on the rooftops of all buildings.

So, therefore, this is our attempt at demonstrating how solar energy will be able to provide to a central utility energy where private investors can buy equipment with the use of tax credits, put them into service in farms where they're able to sell the power and, therefore, have a reasonable business investment and also provide America with a new and exciting energy type equipment.

This particular farm in Borrego Springs—the electricity is sold to San Diego Gas & Electric. The hot water that comes—because our systems are hybrid; they make electricity and hot water—the hot

water is circuited to an alcohol still where we produce ethanol motor fuels and protein. Now, this farm has been under construction for 2 years. This is another thing I'd like to emphasize. When we talk about tax credits, we—we—our company was in business for over 4 years before we ever were able to sell a product that utilized a tax credit, even though the tax credit has been along all the time. It takes a long time to get a project going. It took us over a year to get planning—land-use permits. It took us months and months to get building permits and get through the cities' and the counties', you know, requirements.

We've had to go and engineer and pioneer all types of new equipment to make utility interconnects. Our company has put in these interconnects itself with its own people and, therefore, we're very proud of the fact that we're able to make major utility interconnects now on our own level.

We just recently completed our first multimegawatt interconnector at Borrego Springs this last month and have just started generating power from this farm to San Diego Gas & Electric. As I said, it has taken us 2 years to get this project this far and that's why these projects do not happen overnight.

If a photovoltaic manufacturer already in the business of manufacturing modules started, I dare say it would take a year to 18 months before they could get the project up to a point where they could be generating power.

Mr. McCURDY. How much power is generated at that farm?

Mr. LAMPERT. That farm—this particular farm at Borrego Springs is—is set up to generate 5 megawatts as it's completed over the next few years. We now have a 2-megawatt interconnect completed.

I'd like to also just briefly show—

[Photograph.]

At another farm that we have, which is going to be bigger, which is a 30-megawatt, long-range farm—when I talk about 30 megawatts, I mean a few years to, of course, manufacture. This farm is in Barstow, CA, and is tied to the Southern California Edison grid, which we also just recently completed a major megawatt interconnect at that farm, also. This farm also will produce protein and ethanol motor fuels.

To give you an idea of how the Government helped us do this, even though we put a lot of elbow grease in it ourself, I brought some other photos.

[Photograph.]

Mr. LAMPERT. This is a closeup of what one of these ponds looks like with Fresnel lens concentrators concentrating on to a silicon cell, and this is a photograph—here is a man in the lower right corner. As you can see, it will give you some scale of the size of it, and you can see the farm in the background, and you can see the Fresnel lenses. They float on the water. In our particular design, we can use track systems or water to track the Sun.

[Photograph.]

Mr. LAMPERT. I also would like to point out our 1985 equipment, which is—we just are introducing September 1. This is a Fresnel lens concentrator, which is a hybrid. It puts out 2.5 KW's of elec-

tricity per hour and 40,000 Btu's of hot water. It's a 100-times concentrator, using a Fresnel lens.

Now, let me explain to you about the concentrator and the Fresnel lens in this photo. The Fresnel lens was developed under a DOE contract with Sandia through 3M Corp. 3M manufactures the film that we laminate with acrylics to make this lens. Without that DOE money spent some years ago, we would not have been able to have this lens today, nor would there be what I consider a cost-effective lens available today. This lens does provide us an opportunity to lower our costs into the future with the Fresnel lens.

Also, the solar cell that's under here. I couldn't make a 100-times concentrator cell 2 years ago. Applied Solar Energy, however, which is a company and a very well-respected company in our industry, which is not present here today—we bought our original concentrator cells from them and still do buy cells, even though today we also have our own plant and a capability of making these cells.

Where do these cells come from? Where did—Applied Solar didn't get them overnight. Applied Solar was able to get them because of the fact that DOE, through programs, gave Applied Solar the opportunity to develop the technology.

So you see, our company could not have gotten this far without the past. We're here at the present and we're talking about the future.

What can Congress do? I have some ideas and here's what they come down to. We certainly support the extension of the tax credits in 1990—to 1990, with a 25-percent business credit and a 40-percent residential credit with a \$10,000 cap, meaning that no system could cost over \$10,000. We need certainty of tax treatment with the Internal Revenue Service. The Internal Revenue Service has this year launched a war against abusive tax shelters and I totally support that war because abusive tax shelters are bad for America; they're bad for the investment community and they compete with sheltered investments which are not abusive because of the fact that they take money away or they compete with what we call lower leveraged type investments.

The IRS is confused with these tax credits. They need to have some clear language come from Congress to explain to them that Congress wants these credits to help our industry and that the language be cleared up so that they do not call companies abusive who use the credits, because when the IRS adds up the use of the tax credits in our industry, they compare it to other types of tax leverage programs and because the business energy credit allows an investor to have a more leveraged investment, they consider that to be abusive and we just simply need language to help clear that up and that will, I am sure, be—they will be very happy to have it, too, so they have a guideline or baseline to go by, because they are admittedly confused with how to deal with this credit.

I also have another unpopular statement called domestic content. I don't mean that photovoltaics should be exclusive of any trade considerations, but photovoltaics certainly is a little different than what some of the original trade motives and investment tax credits in the past were meant to help.

We need to keep the U.S. taxpayer's dollar in these tax credits in America. We do not need to have these tax credit dollars help foreign companies expand their technology, their equipment lines. We need to keep the money here in America so that we can develop our own semiconductor type photovoltaic lines or amorphous silicon lines or—in our company's far-out research, we're doing thin film research so that we can continue to do those things.

If we let the funds go to foreign companies, I'm afraid that they will be able to develop the technology faster than we will. They have other Government help and with our Government helping them, they'll have two Governments helping them. We're just trying to get our Government to help us.

Now, an analogy would be, why should we ask for domestic content? Well, photovoltaics is different than most types of equipment that is imported into the United States by foreign companies. If we use the sewing machine analogy, we know that if a sewing machine is built in a foreign country, that when it comes to this country, an American will probably sit at it and use it. Therefore, it creates an American job and, therefore, having that sewing machine be able to be imported at maybe a less cost is an advantage to our country.

But photovoltaic is much different. Once you have it manufactured, it generally just lays in the Sun silently and never does anything again but produce electricity. So no jobs are really created in America once the photovoltaic module is installed. Therefore, it's very important that the photovoltaic module be manufactured in America. We believe that it's important to us. I feel that my company would be injured if we didn't have domestic content. I feel as though that I would be—I would be facing competition far greater than I might be able to compete against if this particular language doesn't get put into the use of the credits.

Also, and I'm almost finished, I certainly support an increase of the DOE programs. Without them in the past, I couldn't be here today and I certainly want to be here in the future and I certainly need their help to do the overview of far-out research looks so that our company will have the access and ability to expand our technological base in the future.

This has been—this is the most critical area of advancing the technology because DOE is able to touch many companies and get a broad-based American scientific support through it, through these programs, and therefore, it comes down to companies—it finally gets filtered back to companies like ours.

So supporting the DOE programs, the SMUD project, of course, are all things that I support.

The export market incentives, of course, might sound contradictory when I talk about domestic content, but we don't have an export market in my estimation. I think that we've done a good job in remote applications around the world, but those are applications where they didn't have electricity anyway and we're talking about how do we take and produce photovoltaic modules into the regular utility markets.

We don't have a product in America or the world today in photovoltaics that can provide the photovoltaic equipment at that cost. I plan—I believe that over the next 5 years, our industry will be able to get to those costs and, therefore, be able to have an export

market where the export assistance will be very, very critical to us to be able to export these products.

Lastly, I'd like to take and, of course, support the Mavroules. I'd like to say that—end up with saying that, you know, we started with the American Revolution. We've certainly become a successful nation with the help of our Industrial Revolution and I certainly believe that the Industrial Revolution will need a solar revolution to help power it into the future.

So with that, I thank you very much for this opportunity.
[The prepared statement of Mr. Lampert follows:]

UEC

420 Lincoln Centre Drive
Foster City, California 94404
415-570-5011 Telex 172 624

September 6, 1984

Ladies and Gentlemen:

The attached statement has been prepared as supporting testimony for the:

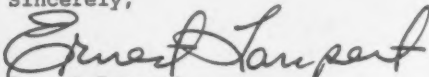
Subcommittee on Energy Development and Applications

Committee on Science and Technology

United States House of Representatives

Verbal testimony will be added to this statement at the hearing scheduled for September 11, 1984.

Sincerely,


Ernest Lampert
President

EL/nq

Attachments

Today the United States photovoltaics industry is at a critical point. Either this industry will prosper strongly or its U.S. development will be substantially curtailed. Timely action is required to ensure that the focus of large-scale commercial development occurs in this country. This result is in the national interest.

In the 1970's, U.S. energy imports and prices were rising quickly with demand. In addition, there were (and are) disincentives to new capital investment by the utility industry. These factors resulted in federal legislation aimed at stimulating the development of renewable energy equipment technologies (photovoltaics, solar thermal, wind, biomass and hydro). The legislation included provision of a business energy tax credit, accelerated depreciation and the requirements of the Public Utility Regulatory Policies Act. This legislation successfully encouraged the rapid development of a variety of renewable energy technologies and products.

UEC has operated since 1978. It is a privately held family corporation. The primary product now manufactured by UEC is a photovoltaic electro/thermal module rated at 2.5 Kw and 40,000 BTU/hour. The product is marketed, primarily in California, through non-exclusive representatives to third party investors who can become independent energy producers and so qualify for the tax benefits that Congress intended.

During the past seven years UEC has: (1) developed technology, and a vertically-integrated (silicon PV concentrator cells, DC/AC inverters and Fresnel Lens fabrication) manufacturing complex; (2) devised and implemented a widely-copied marketing program; (3) manufactured and installed about 7 Mw (electric) of electro/thermal modules; (4) implemented a broadly-based R & D program involving biomass growth and conversion, wind turbine development, aquaculture, alcohol distillation, thin film photovoltaic devices, seawater desalinization and genetic engineering of algae. At present, UEC occupies about 135,000 square feet of office, R & D and manufacturing space in California, Hawaii and India and employs a work force of about 700.

The long-range objective of this activity is to develop and manufacture integrated systems of renewable energy equipment which will produce electrical and thermal energy, liquid fuels, food, potable water, and other products.

The short-range objective of this activity is to develop the knowhow to enable manufacture and sale of photovoltaic/thermal systems which will compete directly with conventional coal, gas or oil-fired generating plants.

There is no doubt that the current level of activity at UEC is related directly to the legislation enacted earlier. The net effect of this legislation is that the market perceives an acceptably low downside risk (in a technology that is not fully proven) with a reasonable expectation for a long-term income stream.

Although UEC may be unique in its scope, we consider ourselves to be typical of the U.S. photovoltaics industry. Without timely government action, UEC and its corporate colleagues will need to restructure their activities and businesses to promote survival rather than growth. Further, it is clear that the general uncertainty regarding extension of the tax credit legislation has resulted in a downturn in the investment climate for renewables. Not only have several photovoltaics (and other renewable energy equipment) manufacturers ceased operation, but many development projects have been undersubscribed or shelved.

In our view, the timely action of the federal government can be divided into action that is necessary, and action that is needed. Four actions are necessary:

1. Extend the expiration date for the business energy tax credit to year-end 1990. This five-year extension will allow for investment lag time.
2. Increase the business energy tax credit for photovoltaics from 15% to 25%. This will provide the capital necessary to achieve both manufacturing cost reductions and credible demonstrations of system performance and reliability.
3. Provide certainty of tax treatment.
4. Increase the funding for the DOE photovoltaics program.

The following actions are needed, in order of priority:

1. Develop 100% domestic content rules for renewable energy products claiming tax credits.
2. Complete the SMUD project to the 100 Mw level in five years.
3. Provide financing assistance for sales in the export market.
4. Implement the Mavroules amendment.

With few market exceptions, photovoltaics (and other renewable energy products) are not yet cost effective unless subsidized; nor are they backed by sufficient performance and reliability data. However, there

is a high probability that these products can be developed into cost effective and reliable solutions for general market penetration without subsidy. The actions of the federal government outlined above are necessary to allow these developments to occur in this country. The following results would be expected:

1. Major New U.S. Industry: With (achievable) cost/performance characteristics, renewable energy products, especially photovoltaics, have a virtually unlimited worldwide market.
2. New Employment: We estimate that, for example, a direct work force of 4,000 would be required for the annual manufacture and installation of 100 Mw of photovoltaics.
3. Other Effects: It is evident that the proper use of renewable energy products leads to a cleaner and safer environment; and contributes toward energy independence and national security.

These results are in the best interests of America.

Mr. Lampert, the founder of the company, has served as President since its inception in 1978 when he made a commitment to develop a renewable energy enterprise on an international basis. Mr. Lampert began his career as a professional airline captain and for ten years owned and operated a government certificated airline. Following the sale of the airline, Mr. Lampert entered the construction industry, developed real estate, manufactured modular housing units, and has developed United Energy Corporation as one of the world's leading renewable energy companies.

Mr. McCURDY. Thank you, Mr. Lampert. I can see your excitement and interest in your business and we're pleased that you were here this morning.

Gentlemen, in the interest of time, we're going to call for the third panel, but if there are any further statements that Mr. Caldwell or Mr. Corsi or anything that you'd like to add at this point, I'd be glad to entertain that.

[No response.]

Mr. McCURDY. We certainly do appreciate your testimony and your statements are quite eloquent and are in the record and the committee and subcommittee will be reviewing those when we issue our report.

Thank you very much.

Mr. CORSI. Thank you very much, Mr. Chairman.

Mr. McCURDY. Now we'll have some of the views from some of the smaller companies within the industry. Mr. Zoltan Kiss, president of Chronar Corp. of Princeton, NJ; and Mr. John Sanders, president of Intersol Power Corp., Lakewood, CO.

They haven't changed the signs yet, so Mr. Zoltan, Mr. Kiss. Zoltan, Kiss, all right.

Gentlemen, we, too—I also want to welcome you and thank you for appearing this morning. We want to finish this hearing—I want to finish this hearing before it becomes afternoon so we don't have too much time, half an hour yet, so if you would like, Mr. Kiss, why don't you make a statement if you'd like and then we'll have questions and Mr. Sanders make his statement and then finish with some questions.

Mr. Kiss.

**STATEMENT OF DR. ZOLTAN KISS, PRESIDENT, CHRONAR CORP.,
PRINCETON, NJ**

Mr. Kiss. Mr. Chairman, thank you for the honor to submit this testimony to your committee—

Mr. McCURDY. Mr. Kiss, you'll need to turn your microphone on there. Push the—there we are.

Thank you.

Mr. Kiss. Mr. Chairman, it is an honor to submit our testimony to this subcommittee on behalf of Chronar Corp. In my capacity as Chronar's president, I also represent a small corporation, small business activity, totally committed to photovoltaics.

Furthermore, our commitment is—at this point is to amorphous silicon thin film technology, but in spite of this somewhat parochial view, I will try to summarize on one hand the state of the art of the various PV technologies as we see it, the state of the PV industry, and finally, some comment on the—for the Government policies to assist the PV industry.

Based on the summary to these hearings, I was somewhat surprised by the implication that, indeed, amorphous silicon technology is not yet here. It has stability problems and its future is somewhat uncertain. To put this in proper perspective, I just briefly would like to review the history of PV technology and the role of amorphous silicon in it.

Over the past two decades the single crystal silicon technology, indeed, has been reduced in cost from initially in excess of \$100 per watt to today where we are approximately \$8 per watt. However, forecasts of cost reductions to the level beyond 1982 just have not materialized. It is a fact that today the cost of single crystal silicon, if anything, has leveled off and started to increase somewhat and this cost, in summary, somewhere around \$8 per watt for single crystal silicon panels, and the comment in the summary to these hearings that this cost can be reduced to the \$2 per watt level is somewhat unrealistic in light of the fact that single crystal silicon technology has benefited very substantially from the integrated circuit industry, investment into this technology of the order of \$200 billion over the past couple decades, direct investment into single crystal silicon photovoltaic technology is in excess of \$500 million and after the substantial investments to reduce the cost from the present roughly \$8 per watt level to \$2 per watt is just—isn't very likely at reasonable investment level.

The thin film technology has been developed over the past two decades, also, in an attempt to find a cost-comparative photovoltaic product for terrestrial application. There have been several different thin films under investigation and development, but I believe at this point, much of the effort of the industry is focusing on amorphous silicon and the product—I brought a panel along. It is basically a piece of glass with four layers of thin film on it, very much like a coated window glass that nowadays is being used in construction of most of the skyscrapers.

The terminal cost of this product is very likely to be similar to that heat-reflecting glass of which last year in the United States, about 100 million square feet was manufactured. The cost of that heat-reflecting glass where you deposit in high vacuum as many as three layers of thin films on the glass, is somewhere around \$5 a square meter. Ultimately, this photovoltaic panel will not cost substantially higher than that heat-reflecting glass.

At the present state of the art, these panels are about 5-percent efficient. A square meter of photovoltaic panel at 5-percent efficiency will give you about 50 watts of electricity, so if you divide the \$5 per square meter, which is the industry cost for the heat-reflecting glass today, by the 50 watts, you end up on the order of 10 cents per watt cost for such coated glass as this amorphous silicon thin film glass is. And this is the terminal cost that one is looking at for thin film technologies.

For single crystal or different versions of crystalline ribbon, while they can be marginally cheaper than the single crystal, it just isn't likely that can reach this type of cost targets.

Today, we are not at 10 cents a watt, but we are today at \$2 per watt manufacturing cost. Also, at our company, we are today on the manufacturing—on the high end of the manufacturing curve, we have 6 percent efficient amorphous silicon large-area panels and at a manufacturing cost of approximately \$2 per watt.

We are completing a manufacturing facility in New York State with a capacity of one megawatt, which we expect to be operational by the end of 1984. We expect to have an additional four-megawatt capacity in the United States by the end of 1985.

Listening to the previous speakers, perhaps the only comment I would like to add is that it really hasn't reflected the rate of development of amorphous silicon technology, both Japan and certainly as we see this industry developing. This technology is here today and—and by the end of this decade, it is going to be here at a cost comparable to the terminal cost that I spoke of the order of 10- to 20-cents-per-watt manufacturing cost for these panels.

Another very important fact to realize, U.S. industry in 1983 has produced approximately 12, 13 megawatts of single crystal capacity. I do not believe that this volume is going to increase substantially this year if at all. Furthermore, in 1984, Japan has already produced more amorphous silicon panels than all other photovoltaic technology combined. And this number is somewhere around 5-megawatt capacity in 1984 in Japan.

Furthermore, there are firm plans—firms committed to reach manufacturing capacity in Japan by the early 1990's of the order of 1 gigawatt or 1 billion watt capacity for amorphous silicon. This is the size of the largest nuclear reactor.

My testimony—there is one comment I would like to add—a sense that amorphous silicon is moving ahead very rapidly on a scale that, before the end of this decade, indeed, it will be available in substantial volume to provide renewable electricity.

The question—the second point that was raised in the summary to these hearings is the stability of amorphous silicon. There has been now substantial studies, both at our company and elsewhere, on the stability of amorphous silicon. The data indicates that at the present state of the art, degradation of the order of 10 to 15 percent over a 15- to 20-year period is realistic and demonstrable. I have some data here to support this.

The longest lifetime studies under excellent conditions that we have done extended over an equivalent 4-year period. Under atmospheric conditions, all-weather conditions, we have had panels about 2-year period, and from these studies, Chronar offers a 5-year warranty of degradation less than 10 percent and we feel comfortable that this will not provide excess exposure to the company.

Briefly, on the commenting on the introduction to the hearings on the difficulties of the photovoltaic industry in the United States, it simply comes about the fact that product was sold at lower price than what it was manufactured at and even though the \$8 per watt manufacturing cost, I believe, if anything, is conservative—this is for assembled panels—prices as low as \$6.50, \$7 selling prices have been in the industry. I think these were made possible partly by some of the tax credit-supported projects that existed.

The further problem was that the commercialization projects have been substantially reduced over the past couple years. The American industry has not gone into the consumer electronic products, which is a very lucrative and profitable business, and taking these factors together, it is not surprising that the American photovoltaic industry did not operate at a profit.

To help this situation, the various proposals that you raised in your memo indeed we strongly support. Probably the most important point is the energy tax credits. The industry's at a state where it is becoming cost-competitive very rapidly with add-on new electricity-generating capacity, but exactly this period of 2 to 5 years,

until it does become totally cost-competitive, but it does need whatever help the Government can provide for it, and certainly tax credits are the simplest, most natural ones.

On this point, I would like to add the comment that it would be interesting to examine the possibility of making the energy tax credits applicable, not only to the energy-producing product, namely photovoltaic panels, but also the manufacturing equipment that makes the photovoltaic panels.

The second point that we would strongly urge is the increase in funding of the commercialization of these—of these projects. In a period when the product is not full cost-competitive on its own merits, again, the smart type of commercialization projects by the DOE could be most helpful to this industry.

The third point we would strongly support is—has been discussed by many others, to provide some financing aid for exports in this industry.

In summary, photovoltaics are not a technology of the next decade; indeed, they are here in this decade and before the end of this decade, they can provide cost-comparative electricity with any new add-on electricity-generating capacity.

Thank you.

[The prepared statement of Mr. Kiss follows:]

CHRONAR

TESTIMONY OF DR. ZOLTAN KISS

PRESIDENT

CHRONAR CORPORATION

U. S. HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON ENERGY DEVELOPMENT
AND
APPLICATIONS

SEPTEMBER 11, 1984

CHRONAR CORP., P.O. BOX 177
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Good Morning. My name is Zoltan Kiss. It is an honor to submit testimony to this subcommittee on behalf of Chronar Corporation, Princeton, New Jersey, on the complex issues confronting this nation's solar photovoltaic industry.

In my capacity as President of Chronar, I also represent the views of small business whose activities are dedicated to the success of photovoltaics (pv). In particular, our company is committed to the manufacture of amorphous silicon photovoltaic panels and products. They represent the marriage of energy and electronics technology via semiconductor electronics.

Going beyond that parochial view, I will address, to the best of my knowledge, the broader issues of interest to your subcommittee:

A. State of the various pv technologies today and in the foreseeable future.

B. State of the pv industry in the United States and around the world, including comments on the market.

C. State of government policies for developing the domestic industry and for assisting exports.

First, however, I wish to offer some background on Chronar, which was founded in 1976 with an investment of \$50,000. Since then, we have invested approximately \$10 million in the amorphous silicon technology -- \$2 million was derived from government funds, \$4 million from a public offering and the balance from our own operations. In contrast to many other companies in the pv industry, Chronar has not been blessed with subsidies from the petroleum or the electronics industry. It is estimated that direct investment in amorphous silicon by those two industries exceeds \$200 million. On top of this, the U.S. government has contributed another \$20 million.

PAGE TWO

PHOTOVOLTAIC TECHNOLOGY

The terrestrial photovoltaic industry has developed over the past decade from a mere bright idea to approximately 20 megawatts of sales worldwide in 1983. This market has been served primarily by single crystal silicon technology. In this period, the manufacturing costs of single crystal panels have fallen from more than \$100 per watt in 1973 to approximately \$8 per watt in 1983. Even though single crystal panels were sold under the \$8 per watt price, it is certain that unless they were subsidized, those sales were made at a loss. Approximately 60 percent of that 20 megawatt market was produced in the United States. Therefore, it is not surprising that the photovoltaic industry, using single crystal silicon, has not operated at a profit.

Furthermore, it should be noted that the cost reductions forecast for single crystal silicon beyond the 1983 timeframe have not materialized, and indeed, during the last year the price of single crystal panels has leveled off and increased slightly. It should also be noted that the single crystal photovoltaic industry has benefitted substantially from the investment in material improvements over the past two decades for single crystal silicon. These investments occurred in the integrated circuit industry (on the order of \$200 billion), as well as specific investments by industry and government in the single crystal photovoltaic development (on the order of \$400 million.) Therefore, it must be said that cost reductions of single crystal silicon panels to the \$2 per watt level quoted in the hearing charter are highly unlikely, assuming any reasonable investment. The economics

PAGE THREE

of single crystal-related products such as polycrystalline silicon, silicon ribbon and others are only marginally better than those of Chakrotsky-grown silicon crystal.

At the same time during the past decade, certain thin film-based photovoltaics were developed, in particular amorphous silicon, which have reached the commercialization stage. This year in Japan, for example, more than 4 megawatts of amorphous silicon will be produced and by 1985 Japan plans to produce more amorphous silicon than all other photovoltaic products. At Chronar, by the end of this year we anticipate a 1 megawatt manufacturing capacity in place, increasing to approximately 5 megawatts at plants across the United States by the end of 1985. The state of the art in the high end of the production curve is in excess of 6 percent efficiency over an active area of 1 square foot and in excess of 5 percent in total area efficiency.

At the present time, manufacturing costs for integrated amorphous silicon panels are approximately \$2 per watt. At Chronar, cost reductions are underway with plans to automate the manufacturing facility and to increase the efficiency to approximately 8 percent from 6 percent. This should reduce panel manufacturing costs to under 50 cents per peak watt by 1988. An example of these panels is shown in Figure 1. The terminal manufacturing cost of 20 cents per watt of such panels at 8 percent efficiency is realistic by 1990. Those costs are also the firmly-targeted costs of the Japanese amorphous silicon program. They are also confirmed by the experience of the solar heat reflecting glass product used in most

PAGE FOUR

modern skyscrapers.

Our product, basically a sheet of glass with three layers of thin film, is similar to the solar heat reflecting glass found on those modern skyscrapers. Last year in the United States, 100 million square feet of heat reflecting glass were manufactured. The manufacturing cost of this glass was around 50 cents a square foot. Now, when you factor in the efficiency of the amorphous silicon photovoltaic product at our ballpark efficiency of 5 percent, a square foot of our product will generate about 5 watts of electricity. So if one is talking about 50 cents a square foot, divide that by 5 watts, and you end up with a 10 cent per watt manufacturing cost for this type of photovoltaic panel. Truly, these cost figures represent the most significant numbers in the photovoltaic industry today.

So, in all fairness, the comments on amorphous silicon in the hearing charter are somewhat misleading. For amorphous silicon will be a cost competitive terrestrial electricity source for major power applications before the end of this decade. The stability problems raised in the hearing charter are manageable. Figure 2 indicates the results of stability data of amorphous silicon, both at Chronar and other institutions here and in Japan. In summary, products delivered after an initial 24 hour burn-in, assuming the present 5 percent efficiency of over a 20 year period, can reasonably be expected to degrade no more than 20 percent of the initial value. Based on such data, Chronar is offering a 5 year warranty for degradation of less than 10 percent in this 5 year period.

PAGE FIVE

Therefore, in determining governmental policy, it should be recognized that amorphous silicon-based photovoltaic products will be available before the end of this decade at a cost that is significantly lower than that of crytalline-based products.

STATE OF THE PHOTOVOLTAIC INDUSTRY

It is a fact that the U.S. photovoltaic industry has operated at a loss for the past years and its future is in jeopardy. When you operate at a loss, it is because you are selling a product for less than what it costs to make it. As I mentioned before, manufacturing costs for these products did not come under \$8 per watt and the major photovoltaic markets will only open up at prices below that. In particular, remote power markets for irrigation, village electrification, refrigeration and others only become cost competitive at approximately \$5 to \$6 per watt and new add-on grid electricity becomes cost competitive at \$2 to \$3 per installed watt. The markets available above these prices -- governmental demonstration projects, high speciality microwave repeaters and similar applications in consumer products (calculator panels that are rechargers) -- become cost effective at \$10 to \$30 per watt. Unfortunately, governmental demonstration projects have dried up and U.S. industry has not participated in the consumer market. These are the main reasons for the industry's troubles today.

PAGE SIX

To open major markets for remote electrification and grid-competitive electricity, manufacturing costs of the panels have to be brought down to substantially under \$2 per watt. This is only possible with thin film technology. For the United States to ignore this fact, at this crucial stage of development, and to bet on single crystal silicon and other high cost materials is tantamount to surrendering leadership in this strategically and economically important industry.

GOVERNMENT POLICY

Unfortunately, the U.S. government is showing signs of losing interest in this important technology now that the spectre of gasoline lines and energy shortages is receding into history. The solar industry campaigned hard to extend the tax credits for solar pv use in businesses and homes in the Tax Reform Act of 1984. The effort to extend the business and residential energy taxes beyond their current 1985 date of expiration failed in conference and was left to the uncertain fate of congressional hearing in the 99th Congress. At Chronar, we were sorely disappointed for we believe that we need the incentives of the tax credits, as well as government-supported demonstration projects and incentives to expand manufacturing capacity if we are to create a sound and viable domestic base for the solar pv industry. A base we can use to sell U.S. solar technology both in the United States and abroad. Currently, Chronar is competing mightily in the international arena. Without strong encouragement in the domestic arena, and the support afforded by the business

PAGE SEVEN

and residential energy credits, I fear that our international effort will lose ground to that of the Japanese who have mounted an equally determined effort to sell abroad. This would be yet another example of how the United States first led in the creation of a technology only to see its commercial application be exploited by others. Beyond the energy tax credits, we would like to see a more aggressive, positive stance taken by the Export-Import Bank, OPIC and by the Department of Commerce in its foreign operations. Solar pv is no longer a high risk R&D phenomenon. It is a rapidly improving commercial technology that offers remarkable opportunities for expansion both domestically and worldwide in many varied applications. The U.S. government should be doing all in its power, consistent with its free market philosophy, to encourage U.S. preeminence in this field. The benefits are too numerous to ignore: environmental (no acid rain, no water pollution, modularity); strategic (energy self-sufficiency); and socio-economic (lower cost electricity).

Thank you. I would be pleased to answer your questions.

Mr. McCURDY. Thank you, Dr. Kiss.
Mr. Sanders.

STATEMENT OF JOHN SANDERS, PRESIDENT, INTERSOL POWER CORP., LAKEWOOD, CO

Mr. SANDERS. Mr. Chairman, I am the president of Intersol Power Corp., who is a privately held corporation, looking for capital, and so we have a very unique opportunity to discuss the problems of working with investors in private investment communities in the United States.

We started back in—in 1974 and we're—and worked with the Department of Energy and all the other support organizations since that time, part as Martin Marietta in the aerospace organizations and now as Intersol Power Corp. We're systems integrators and we are manufacturers of photovoltaic concentrators. We currently have the highest efficiency modules and array system in the world.

Over that 10-year period, one of the things that hasn't come out of this discussion so far—the concentrators showed in many aerospace company cost studies that it could achieve \$2.50 a watt system installed price at a 100-megawatt level. This certainly competes with the fossil fuel industry of today.

The hearing comments were that the industry is in trouble. I think what we're seeing is a classical industry evolutionary problem. The shake-out of the uneconomic and nonefficient manufacturing organizations and the uneconomic technologies. We also have survival of mature technologies and what we require now is the additional support to make those mature technologies proceed.

One of the problems that we are seeing in trying to get capitalization for the company is the lack of long-term Government policy, which is inhibiting our ability to grow because of the lack of opportunity for the investors to see a future in the business.

The prerequisites of the photovoltaics industry is the same as the prerequisites of any industry. You have to have a market. That market can only be available if you've got the price right and you have to have the production capability to meet that price.

In the photovoltaics industry, you also have other unique things. You have to have benefits that supersede the fossil fuel industry and any other alternative energies that are available at this time. The DOE focus—focus in the 10 years of research and development that we have seen was on flat plate. It was a natural offshoot of the aerospace technology. It is proven with single crystal silicon that even with the economies of scale, their systems installed price of \$10 a watt is uneconomic for future investments.

Conversely, with the concentrators, the DOE awarded contracts to the aerospace technologies—aerospace organizations. Here, we saw a typical use of the high technology that's being developed through the Government in producing high-efficiency, low-cost systems. Unfortunately, the aerospace companies have high overhead; they are typically tied up with cost-plus fixed-fee contracts and to commercialize in that environment is very, very difficult.

Fortunately, there are also spinoffs from that—from the aerospace organizations and there are two remaining entities. Both of these companies have the highest-efficiency modules in the world at this point in time.

The problem with the industry is it can't sustain itself without incentives. The earlier panel discussions talked about \$4 a watt and that requires approximately 20 megawatts of annual produc-

tion to ensure industry growth or even sustain the existing markets.

These multimegawatt contracts—they are absolutely required to achieve 20 megawatts of annual production—require planning and multidisciplines, including architectural engineers and public utilities. Part of that problem is that the architectural engineers are very important to the survival of the photovoltaics industry and so are public utilities. Public utilities don't have any incentives, which has been mentioned earlier, and the architectural engineers will make their money whether it's fossil fuels, nuclear, wind farms or photovoltaics. So they don't have the incentive.

As far as concentrators, I believe that's a near-term solution. I have been quoting for the past several years that I can produce 1 megawatt at \$7 per watt installed capacity. We have firm prices at 5 megawatts at \$5 per watt. We have manufacturing capabilities now of 2 megawatts per year.

The installation—the manufacturing facilities for concentrators are a lot different to flat plates. We do not need \$40 million, as Spire Corp. mentioned this morning, for a large multimegawatt system. We're systems integrators. We use the U.S. infrastructure to supply our hardware. We use the industrial might of the United States to give us the hardware we require. Only special, very small specialized units have to be built and specialized—a small amount of specialized tooling needed. So, for a 20- to 50-megawatt plant, we're looking at something less than \$8 million.

I don't believe from a cost-sharing viewpoint that the Government should be involved. It inhibits commercial sales and it doesn't generate the market that's needed for that production facility anyway. The opportunity of using low-interest loans is very important, however.

As far as export is concerned, I believe that the Japanese and the Europeans have been exporting—that's been their lifeblood for the last several hundred years. The United States doesn't know how to do it to this point in time and it's more fundamental of the U.S. policy in export, rather than photovoltaic problem.

I believe, and I have had a distinct experience with one of the largest installations abroad, which was the Soleras 350-kilowatt system in Saudi Arabia. That system would have only cost half the price to install in the United States. The U.S. Government spent its money to put a demonstration project in a country that you can't get into to see, which is very important for the industry, and we could have installed it in this country for the same price—for half the price.

There are tremendous barriers and certain small companies like ourselves can't afford to go. Those countries that typically need the power have got no money anyway and so you have to go through the USAID projects and we go through that exercise of ineffective and inefficient usage of money.

I believe the aggressive implementation of the Mavroules Act is very important to us, but as the act specifies, it must meet lifecycle cost goals. That can only be done by having large production facilities and markets that can take that production facility at the price—the production level.

In that case, you need a central purchaser for the Department of Defense to procure bulk energy products. There's no point in shotgunning the industry. All it does is keep the price high because you share the wealth.

Research and development through the Department of Energy has upgraded the state of the art to a very mature technology at this point which can be commercially available. Back in the early days, there was funds available for demonstration projects. Those funds are not available today. The 100-megawatt SMUD program is certainly one of those opportunities. However, if it goes—if phase III follows phase I and II, it will be utilizing uneconomic technologies; it will be spreading schedules so far out that it will be too late to save the industry; and I'm not too sure what type of technology we'll use.

I believe that it needs more DOE participation. It certainly needs more A&E participation and more public utilities involved in the whole operation.

The solar tax credits, I believe, are the most effective way of allowing the photovoltaics industry to grow. It's also the most abused and we have a typical problem here. We have a subsidy of uneconomic technologies, but more important, we have a subsidy of economic technologies such as wind farms. These wind farms, where they're already cost effective, the private investment community is investing in those opportunities and yielding higher returns on investment than they would get in the photovoltaic application, and therefore, is restricting our method of growing.

As far as the 25-percent energy tax credit is concerned, I'm not too sure that that is the right thing for the industry. I think it will further subsidize uneconomic technologies. I believe that extending the credits now will allow the valuable technologies now to proceed. However, I believe that a 1987 time period is the right time period and that a grandfather clause should be put in to allow large-volume orders to be placed before the end of the period. That will also achieve economies of scale, which we so desperately need.

The other problem with the solar energy tax credit is the way it is established now, the private investor sees too short a time period to commercialize. The problem is if we extend it into the 1990's or 1990, they will sit on a fence and wait for new technologies to come up, and we have seen this in our experience touring Wall Street.

In summary, I don't think the industry is in trouble. I believe we can get 20-megawatt manufacturing capacities for about \$8 million. I believe we can sell 20-megawatt systems for \$4 per watt, installed. The concentrators are the only near-term viability and the only near-term systems that can achieve those prices. We do need minor modifications to the Government incentives. I think low-interest loans for capitalization of the factories and also capitalization of the facilities is very important. I think energy tax credits should be extended to 1987 with grandfather clause and I think we should implement and be more aggressive with Mavroules amendment and apply bulk energy purchases and we should restructure SMUD.

I think the United States is a world leader. We can export energy; we have that opportunity, and it will help our balance of payments. It will give us significant employment in the future and

it will release oil for future constructive uses, rather than burning it.

Thank you very much.

[The prepared statement of Mr. Sanders follows:]

TESTIMONY OF
JOHN A. SANDERS
TO THE COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

SEPTEMBER 11th, 1984

SUBJECT:

HEARING BEFORE THE SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS
ON THE CURRENT STATE AND FUTURE PROSPECTS
OF THE U.S. PHOTOVOLTAICS INDUSTRY

Introduction

In the 1970's, the U.S. Government embarked on an ambitious program to find alternative sources of energy offering economic solutions to the problems created by the first oil crisis. One promising near-term solution is the production of electricity by photovoltaics.

Ten years of research and development confirms the production of electrical energy through the use of photovoltaics (PV) can be achieved at lower costs than fossil fuels. A new photovoltaic's industry uniquely U.S. instigated, will reduce our dependence on foreign oil, improve our balance of payments through reduced oil purchases and the sale of power (PV systems), help clean up the environment and ensure economic growth for future generations.

The evolutionary photovoltaic industry today is in the state of confusion. As in other high technology industries, shake-out of uneconomical technologies and non-commercial manufacturers have occurred at the same time that more survivable technologies are maturing. Simultaneously, the lack of a Government long-term alternative energy policy restricts investments and creates a lack of public interest in mature technologies which can meet the necessary cost parameters for PV industry growth.

The prerequisites of the photovoltaic industry to succeed is typical for most industries:

1. The product must be priced right to create market demand.
2. Market demand must be large enough to capitalize for volume production to achieve economies of scale.
3. The product benefits must be superior to alternate approaches which are available to the end user.

Photovoltaic Industry Shake-Out

Industry stimulus, through Government funded programs, focussed on flat-plate single crystal silicon module development. As a result, this product matured first and found markets in low power, remote applications. Although the available market secured multi-megawatts of production, costs below \$10 per watt were not realized in spite of the advantage of "economies of scale". Future markets at this price are inadequate to sustain the industry. The PV industry shake-out in the flat-plate sector has been largely economic, and aggravated by an inability to achieve low module prices.

The concentrator shake-out is more dramatic considering the companies involved are General Electric, Martin Marietta, Motorola, and 'E' Systems. The Department of Energy (DOE) research and development awards to these aerospace companies were necessary to integrate the multi-disciplined technologies required to develop the concentrator system. These efforts resulted in successful high efficiency designs, which several years ago, showed that DOE's cost goal of \$2.50 per watt is achievable. Unfortunately, when the time was opportune to commercialize these successful products, the aerospace companies were not organized to implement low cost projects. The high overhead, "overkill" aerospace approach to business, combined with a cost-plus-fixed-fee contracting atmosphere detracted from their ability to achieve low cost objectives. Fortunately, Intersol Power Corporation and Entech were able to spin off and form commercially oriented corporations with the support and confidence of the Department of Energy. Both companies are projecting PV installed costs of less than \$3.00 per watt at a 50 MW production volume, however, they are 1981-1982 start-up companies with limited capitalization.

The Problem

The photovoltaics industry cannot sustain itself without tax credits, or other incentives if installed system prices

exceed \$4.00 per watt, and the system price cannot be achieved unless production volume approaches 20 megawatts per year. Markets of this magnitude are unlikely to develop without multi-megawatt installations connected to public utilities or large industrial complexes. Herein lies the problem - the utilities and investment community have defined their requirements:

1. Installed price below \$4.00 per watt.
2. Systems must have high efficiency to justify installation costs.
3. System must have high reliability and low maintenance costs.
4. System manufacture and installation must use high quality products and be composed of a partnership.
5. Supplier must guarantee quality and performance.

These requirements immediately identify critical issues that have not been adequately addressed by current Government incentives or the photovoltaics industry.

1. Public utilities lack incentives to participate.
2. Architectural and Engineering (A&E) companies are required for an acceptable partnership.
3. The PV flat-plate industry is generally structured to sell modules, not systems, and its research and development efforts suggest a trend to lower efficiency systems, contrary to large system requirements.

Lack of incentives and partnerships are the major issues. In particular the A&E's are not dedicated to photovoltaics, typically only interested in very large systems, and in search of short-term profits, not long-term survival. In short, whatever energy source prevails in the future, the A&E will participate.

Near-Term Solutions

The near-term viability of the PV industry lies in high volume concentrator sales, and perhaps crystalline and silicon

sheet technology. Near-term amorphous applications are consumer goods dominated by the Japanese. Concentrator manufacturers are achieving high efficiencies, are typically systems integrators and are therefore in concert with large system requirements. Conversely, the ribbon and crystalline technologies offer only moderate efficiencies where the manufacturer focusses on module production and therefore requires significant A&E participation.

The near-term health, and perhaps the survival of the PV industry in the United States, will rest upon producing sufficiently large quantities of hardware to get the price right, and generate a market for the total product. Government incentives are the only sure method by which this can be achieved. You are familiar with the various incentives.

1. Government cost sharing of production lines.
2. Financing assistance for export markets.
3. Implementation of the 1983 Mavroules Amendment.
4. Completion of the SMUD Project.
5. Extension of the energy tax credits.

1. Government Cost Sharing of Production Lines

Government cost sharing in the establishment of production facilities would aid in having the ability to produce the quantities of hardware necessary to achieve the cost objectives but not the market necessary to sell the product in volume. We must also recognize that Government support of commercial facilities inhibits the sale of the hardware in the commercial market place and does not, therefore, enhance the ability to provide industry growth. Government support should be oriented towards the procurement of the product. When the appropriate sales are achieved, the manufacturer is able to capitalize via a wide variety of sources. Historically, successful Government support of manufacture has been accomplished through low interest loans.

2. Financing Assistance for Export Markets

The export market is extremely large at the right price. Although this price may be nominally higher than the domestic U.S. market price for large systems, it is still contingent on large volume production and corresponding sales volume. Past demonstrations of Government assisted projects have failed to achieve their objectives. The Soleras, 350 kW system would have only cost half of what it actually cost installed in the U.S. instead of Saudi Arabia, and greater visibility would have resulted. Export marketing costs are extremely high, and the return on investment often questionable. Obtaining U.S. Government assistance is time consuming, foreign country barriers are extensive and most countries requiring the energy have little money especially for complete systems. Government assistance must be focussed on the domestic market place. When cost objectives are met in the U.S. the foreign market will naturally occur.

2. Implementation of the 1983 Mavroules Amendment

Government purchases of PV systems through the aggressive implementation of the 1983 Mavroules Amendment could play an important role in achieving the cost goals of the industry. Since life cycle cost is a major criteria for Government purchases, the PV installed costs will still have to approach the \$4.00 per watt target.

In order for the Mavroules Amendment to be effective in stimulating the industry, it is necessary to issue contracts in large energy blocks to allow economies of scale to be achieved. The issuance of kilowatt contracts for individual projects will signal the ultimate collapse of an industry which cannot achieve the cost goals.

D. Completion of the SMUD Project

The continued efforts in support of research and development

by the Department of Energy provides the means to upgrade the state of the art. Large demonstration projects are needed now to evaluate the latest designs in the area of performance, reliability and cost.

The planned 100 MW SMUD project has the potential to demonstrate the near term viability of PV if the appropriate technologies are selected, and also provide the volume orders to meet cost goals. The project to date, however, has shown a lack of initiative by selecting proven uneconomical module technologies for phase I and II, and scheduled phase I and II completions are far in excess of those achieved in the private sector.

Phase III bid processes exclude PV manufacturers from being prime placing the selection of the PV technology in the hands of the A&E. The selection process for the A&E is extremely restrictive and prevents innovative and cost effective selections to be made.

In order for the SMUD project to be effective, the Department of Energy should be more involved with the decision making process. The scheduling of phase III must be accelerated if it is to contribute to the survival of the industry and promote the most effective technologies.

5. Extension of the Solar Tax Credits

Solar business tax credits are the most effective incentives to achieve photovoltaic commercialization. Unfortunately, these credits are also the most abused and are used to support uneconomic projects which are non-competitive in high volume production. In other cases, they have been used on cost effective projects such as wind farms for increasing profits, detracting private investors from viable PV projects.

The positive attitude of the investment community is crucial to capitalization of manufacturing facilities. If the time period

for the solar tax credits are short, then there is concern about inadequate time to commercialize. When the time period is extended, the attitude is to wait and see, and reduce the risk.

The maturing PV technologies are now in position to utilize the credits to supplement the higher priced initial production, and enable economies of scale to achieve a \$4.00 per watt cost goal for non-Government supported markets. The credits, however, are due to end in 1985 cutting too short the time to plan projects of sufficient magnitude to achieve Government independence for this critical energy industry.

Increasing the tax credits up to 25% will clearly assist the viable technologies but will also supplement uneconomic systems to the detriment of the more viable technologies. Most important, the existing credits must be extended to 1987 to allow sufficient time to plan and achieve large scale PV sales and production. Realistic extensions must include "grandfather" clauses which shorten the extension, and provide incentives to system investors to procure in large volumes, rather than spread orders over several years.

Summary

The photovoltaic industry is in trouble and will probably collapse without short-term Government assistance. Continued support through Government incentives focussed on high productivity, and large installations will permit the existing viable options, particularly concentrators, to break through the price barriers. When these barriers are broken, credibility will have been proven and the investment community will participate in the industries future.

With minor modifications, the Government incentives now in place provide effective tools for photovoltaic commercialization. Applications and implementation of these incentives are as follows:

1. Low interest loans for capitalization of photovoltaic

manufacturing facilities and large demonstration projects.

2. Extension of the energy tax credits through 1987 incorporating a grandfather clause to provide incentives for investors to buy in bulk.
3. Aggressive implementation of the 1983 Mavroules Amendment with centralized purchase of bulk energy.
4. Restructuring of the SMUD program to obtain timely participation of the viable technologies and greater flexibility in selection of aggressive A&E's.

The motivating force behind the photovoltaic industry has been the U.S. Government. We have an edge on the technology and have the ability to be world leaders in the manufacture and export of the energy source of the future. Without further near-term Government support, this opportunity will be lost to Japan and Europe.

We must release oil for more constructive purposes and avoid the threat of a third oil crisis and the subsequent recession.

Mr. McCURDY. Thank you, Mr. Sanders.

Dr. Kiss, I just—we're about out of time here, but I want to give you an opportunity—any followup response or perhaps see if there's anything that you disagree with with what Mr. Sanders said as far as assistance to companies of your size.

Mr. Kiss. Well, I guess substantively we do not disagree with Mr. Sanders. Perhaps I would be more encouraging on the energy tax credits extended for a full 5 years. I believe, while he's correct, it will help somewhat obsolete technologies, but it will also help new emerging technologies.

Mr. McCURDY. Do you agree on cost-sharing? Mr. Little earlier, who's sitting behind you there, raised that point and I wanted to—to make sure that everyone had an opportunity to view that because that probably is one of the more controversial issues and I want to get that clarified.

Mr. Kiss. Well, cost-sharing of the manufacturing facilities is a difficult issue. My suggestion there was perhaps extend the tax credits also for manufacturing equipment to the photovoltaic industry, combined with low-interest loans, perhaps might be an easier way to accomplish the task.

Mr. McCURDY. Very good.

Gentlemen, thank you very much. Your statements are a portion of the record and on behalf of the chairman, who, again, sends his regrets that he is unable to be here today, we want to express our appreciation for the very thoughtful testimony that you've provided.

With that, the committee's adjourned.

[Whereupon, at 12 noon, the subcommittee was adjourned, to reconvene subject to the call of the Chair.]

THE CURRENT STATE AND FUTURE PROSPECTS OF THE U.S. PHOTOVOLTAICS INDUSTRY

WEDNESDAY, SEPTEMBER 19, 1984

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:13 p.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Ottinger, Boucher, Schneider, Lewis, and Carney.

Staff present: Dr. Eugene Frankel, science consultant; and William T. Harvey, minority energy consultant.

Mr. FUQUA. Today, we conclude our hearings on the current state and future prospects of the U.S. photovoltaics industry. Last Tuesday, on the opening day of the hearings, there was disagreement over whether or not the photovoltaics industry is in trouble or whether or not today's technology can meet the Department of Energy's cost goals, and whether or not the Government should assist industry to set up large-scale production lines.

However, there was strong agreement among the witnesses on three key findings: First, the extension and expansion of the renewable energy tax credits is vital to the continued health and long-term growth of this important industry. Second, export sales are a significant fraction of the country's business and need to be vigorously promoted and assisted by the Government. Third, Federal agencies can assist the photovoltaics industry by purchasing such systems whenever they are life-cycle cost effective.

The subcommittee has spent a great deal of time on the renewable energy tax credits, and the record in support of their extension is extensive. Today, we want to look at the other two incentives, promotion of export sales and purchases by Federal agencies, which can provide additional support to the industry.

We have with us witnesses who are well qualified to address these issues: Congressmen who have sponsored successful legislation dealing with Government purchases and export sales; solar businessmen who have extensive experience with U.S. Government and foreign markets; solar trade association representatives with expertise in these areas; and spokesmen for the lead agencies in Government purchasing and promotion of exports, the Departments of Defense and Commerce.

Before we begin, Congressman Winn has a statement which, without objection, I would like to have inserted in the record at this point.

[The prepared statement of Mr. Winn follows:]

OPENING STATEMENT BY
THE HONORABLE LARRY WINN, JR.

U.S. PHOTOVOLTAICS INDUSTRY
SEPTEMBER 19, 1984

THANK YOU, MR. CHAIRMAN, FOR THIS OPPORTUNITY TO WELCOME OUR WITNESSES TODAY. THEY REPRESENT THE INTERNATIONAL AND THE U.S. GOVERNMENT MARKETS AND SHOULD GIVE US A SIGNIFICANT PERSPECTIVE OF THAT CUSTOMER BASE. WE ALSO WELCOME THE HONORABLE NICHOLAS MAVROULES, MEMBER OF CONGRESS, AND FORMER MEMBER OF THIS COMMITTEE.

AS THE SECOND OF A TWO-PART HEARING ON THE PHOTOVOLTAICS INDUSTRY, WE PICK UP FROM THE INDUSTRY OVERVIEW WHICH WE RECEIVED DURING THE SEPTEMBER 11, 1984, HEARING. IN THAT EARLIER HEARING, WE RECEIVED TWO DIFFERENT OPINIONS ON THE NECESSITY FOR TAX CREDITS TO FURTHER THIS INDUSTRY: THOSE WHO FAVORED CONTINUATION AND THOSE WHO DID NOT. POSSIBLY WE CAN BE FURTHER ENLIGHTENED TODAY ON THAT ASPECT.

THE EMERGENCE OF THE U.S. PHOTOVOLTAICS INDUSTRY IS ONE OF PARTICULAR INTEREST AND PRIDE TO ME. THROUGH ITS CONCEPT AND ITS INFANCY, THE PHOTOVOLTAICS PROCESS HAS BEEN STRONGLY SUPPORTED BY THIS COMMITTEE. OVER \$500 MILLION IN GOVERNMENT FUNDING HAS BEEN SPENT IN RESEARCH DURING THE LAST TEN YEARS. IT IS VERY SATISFYING TO SEE ITS EMERGENCE AS A VIABLE ENERGY SOURCE. I WILL CERTAINLY VIEW ITS CONTINUED GROWTH WITH INTEREST. WE SEE HERE THE CASE OF MANY SMALL COMPANIES ENTERING AN ATTRACTIVE FIELD. THE MAJORITY ARE HIGHLY

QUALIFIED, MOTIVATED AND COMPETENT. I SUSPECT THAT IN THE NOT-TOO-DISTANT FUTURE, WE WILL SEE SOME OF THEM DISAPPEAR FROM THE SCENE, EITHER THROUGH MERGER, PURCHASE, OR FAILURE. ONCE AGAIN, A CLASSIC EXAMPLE OF AMERICAN FREE ENTERPRISE.

ON THE OTHER HAND, THERE ARE THOSE WHO WOULD TAMPER WITH THE ECONOMIC PROCESS. VARIOUS SUBSIDIES AND ARTIFICIAL DEMAND MIGHT BOLSTER SOME FIRMS AT THIS TIME AND IN THE IMMEDIATE FUTURE. HOWEVER, I BELIEVE THAT RELIEF WOULD BE MINIMAL AND NEAR-TERM ONLY. ON THE OTHER HAND, THE INDUSTRY WILL CERTAINLY PROFIT FROM THE RESEARCH BEING SPONSORED BY THE U.S. DEPARTMENT OF ENERGY AND AUTHORIZED BY THIS COMMITTEE. I AM AWARE OF FUNDAMENTAL STUDIES OCCURRING AT THE SOLAR ENERGY RESEARCH INSTITUTE AND OTHER SITES WHICH SEEK TO UNDERSTAND BASIC RELATIONSHIPS, LEADING TO IMPROVED MATERIALS AND EFFICIENCIES. A RECENT STAFF VISIT TO THE SOLAR ENERGY RESEARCH INSTITUTE REPORTED THAT INDUSTRY-GOVERNMENT RELATIONSHIPS APPEAR TO BE CLOSE AND MUTUALLY BENEFICIAL. SURELY, THE COMMITTEE WILL CONTINUE TO SUPPORT THAT KIND OF ACTIVITY.

AGAIN, MR. CHAIRMAN, WE LOOK FORWARD TO THIS ADDITIONAL TESTIMONY FROM THE PHOTOVOLTAICS INDUSTRY. IT SHOULD PROVIDE HELPFUL GUIDANCE TO US IN THE SUBSEQUENT FUNDING REVIEWS.

Mr. FUQUA. Also, without objection, permission will be granted to take photographs and make recordings of the proceedings today, retroactively. [Laughter.]

Our first witnesses today will be Congressman Mavroules, a Member of Congress from Massachusetts; and Congressman Ron Wyden whom I don't think is here at this time.

Congressman Mavroules, we are pleased to have you, a former member of this committee and a man that has great respect, not only in the Congress but outside.

**STATEMENT OF HON. NICHOLAS MAVROULES, A U.S.
REPRESENTATIVE FROM THE STATE OF MASSACHUSETTS**

Mr. MAVROULES. Thank you very much, Mr. Chairman. I certainly thank you for the opportunity to speak before you today and for the privilege of joining my colleagues on the panel. I understand that I have been requested to perhaps spend some time with you, and I appreciate that opportunity.

Mr. Chairman, your subcommittee has been addressing the issue of the viability of the photovoltaics industry. In the first day of testimony, several leaders in the field of photovoltaics spoke of the need to extend energy tax credits, and they endorsed a policy of aggressive implementation of my 1983 amendment to the Military Construction Authorization Act. For that, I certainly appreciate their support and interest. Indeed, before and since enactment of that amendment, my office has been deluged with requests for information from energy companies across the country, most seeing this as a means of expanding their own markets.

For those here who are not completely familiar with my amendment, I would like to backtrack a moment and outline the reasons and purposes behind my measure.

The 1973 Arab oil embargo alerted all Americans, particularly the Defense Department, to the vulnerability of their dependence on petroleum products. The military simply cannot afford to be immobilized by interruptions in supply lines that are dependent on a foreign nation's whims.

The world has changed in these last 11 years, Mr. Chairman, and we may never again be faced with a situation of the impact of the 1973 oil embargo, but neither should we wait around to see. The situation won't be getting any better. New oil discoveries will continue to be less than consumption, and despite a reduction in oil consumption by the United States, our allies are still very dependent on oil from foreign sources.

I think it behooves the Defense Department to support congressional efforts to demonstrate to the American people not only the seriousness of our energy problems, but also what alternatives are available and can be stimulated by proper Government action and policy.

Without the introduction of renewable forms of energy to the DOD's energy mix, I cannot see any improvement in the Department's status as the single largest user of oil in the nation. Mainly because of the demand by aircraft and ships, some 81 percent of DOD's total energy needs must be met by petroleum products.

While developing innovative alternative energy sources to meet DOD's transportation needs may take more time, renewable energy sources can provide DOD today with an inexhaustible and reliable energy source for its electrical power generation needs.

My amendment, founded on the belief that energy security is national security, would ask the Secretary of Defense to play a greater role in reshaping the Department's own energy needs and thus attain a high level of military preparedness. It calls for the Department to procure energy systems powered by photovoltaics and other renewable forms of energy wherever cost-effective and applicable and for the Department to use photovoltaics and other renewable forms of energy in new facilities, again, wherever cost-effective and applicable, thereby making these facilities and installations relatively energy self-sufficient.

At this point, Mr. Chairman, I ask that a copy of my 1983 amendment be included in the record.

Mr. FUQUA. Without objection, so ordered.

[Copy of amendment follows:]

97TH CONGRESS
2D SESSION

H. R. 6214

To authorize certain construction at military installations for fiscal year 1983, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

APRIL 29, 1982

Mr. BRINKLEY (for himself and Mr. TRIBLE) introduced the following bill; which was referred to the Committee on Armed Services

A BILL

To authorize certain construction at military installations for fiscal year 1983, and for other purposes.

- 1 *Be it enacted by the Senate and House of Representa-*
- 2 *tives of the United States of America in Congress assembled,*
- 3 That this Act may be cited as the "Military Construction
- 4 Authorization Act, 1983".

17 USE OF RENEWABLE FORMS OF ENERGY

18 SEC. 803. (a)(1) Chapter 141 of title 10, United States
19 Code, is amended by adding after section 2393 the following
20 new section:

21 "§ 2394. Procurement of energy systems powered by re-
22 newable forms of energy

23 "(a) The Secretary of each military department shall
24 procure energy systems using solar energy, or other renew-
25 able forms of energy, whenever the Secretary of a military

1 department determines that such procurement is possible and
2 will be cost effective, reliable, and otherwise suited to supply-
3 ing the energy needs of the military department (such as
4 energy systems powered by solar energy, or other renewable
5 forms of energy, to supply energy for mobile power systems,
6 cathodic protection of pipelines, remote communications sites,
7 mobile radar sites, navigational aids, military range monitor-
8 ing and conditioning equipment, load center power, water
9 pumping and purification, cathodic protection of water towers
10 and bridges, perimeter security devices, data links, repeater
11 stations, emergency and rescue communications, lighting,
12 remote instrumentation, marking and warning devices, moni-
13 toring and sensing devices, and remote weather stations and
14 transmitters).

15 “(b)(1) For purposes of carrying out subsection (a) and
16 section 2688, the Secretary of Defense shall study applica-
17 tions for the use of solar energy, and other renewable forms
18 of energy which are cost effective and reliable to supply the
19 energy needs of the Department of Defense.

20 “(2) Not later than the date occurring two years after
21 the date of the enactment of this section, and not later than
22 the date occurring two years after each such previous date,
23 the Secretary of Defense shall submit to the Committee on
24 Armed Services of the Senate and the Committee on Armed
25 Services of the House of Representatives a report on the

1 findings of the studies conducted pursuant to paragraph (1)
2 and containing any recommendations for legislative action.

3 “(c) For purposes of this section—

4 “(1) energy system using solar energy, or other
5 renewable forms of energy, shall be considered to be
6 cost effective if the original investment cost differential
7 can be recovered over the expected life of the facility
8 using accepted life-cycle costing procedures. Such ac-
9 cepted life-cycle costing procedures shall include the
10 use of the sum of all capital, operating, and mainte-
11 nance expenses associated with the energy system of
12 the building involved over the expected life of such
13 system or during a period of twenty-five years, which-
14 ever is shorter, and using marginal fuel cost as deter-
15 mined by the Secretary of Defense and at a discount
16 rate of 7 per centum per year. For the purposes of a
17 life-cycle cost analysis under this subsection, the origi-
18 nal investment cost of an energy system using solar
19 energy, or other renewable forms of energy, shall be
20 reduced 10 percent as an investment cost credit; and

21 “(2) the term ‘energy system’ includes any energy
22 system which generates electricity.”.

23 (2) The table of sections at the beginning of chapter 141
24 of title 10, United States Code, is amended by adding after
25 the item relating to section 2393 the following new item:

“2394. Procurement of energy systems using renewable forms of energy.”.

1 (b)(1) Section 2688 of title 10, United States Code, is
2 amended—

3 (A) in subsection (a)—

4 (i) by striking out “solar energy systems” in
5 the first sentence and inserting in lieu thereof
6 “energy systems using solar energy, or other re-
7 newable forms of energy (including systems that
8 produce electricity),”;

9 (ii) by striking out “solar energy has” in the
10 first sentence and inserting in lieu thereof “such
11 systems have”; and

12 (iii) by striking out “solar energy systems” in
13 the second sentence and inserting in lieu thereof
14 “such energy systems”; and

15 (B) in subsection (b) by striking out “a solar
16 energy system” both places it appears, in the first sen-
17 tence and in the third sentence, and inserting in lieu
18 thereof “an energy system using solar energy, or other
19 renewable forms of energy (including any system pro-
20 ducing electricity),”.

21 (2) The heading of section 2688 of title 10, United
22 States Code, is amended to read as follows:

1 "§ 2688. Use of renewable forms of energy in new facili-
2 ties"

3 (3) The item in the table of sections of chapter 159 of
4 title 10, United States Code, relating to section 2688 is
5 amended to read as follows:

"2688. Use of renewable forms of energy in new facilities."

I recognize that some concerns were raised by earlier witnesses that we cannot force any customer, whether it is the Department of Defense or a private company, to buy a product, and that certainly is true. However, let me read for a moment from a study released by the DOD in 1977 that dealt with solar energy commercialization. This study, entitled "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis," stated that,

Photovoltaics offer a number of advantages to the DOD. In addition to potential cost and fuel savings, photovoltaic energy systems would provide the DOD a highly reliable, silent power source allowing virtually unattended operation in most areas of the world. Near term benefits to the DOD include cost and logistics savings at remote sites, in portable equipment and offshore applications.

The report continues on to say,

The U.S. would also receive national benefits from accelerated commercialization of photovoltaics. Over the longer term, photovoltaic energy systems will offer the nation a cost competitive source of commercial electric power, thus reducing dependence on foreign energy sources. Other national benefits include the development of exports to underdeveloped countries where photovoltaic systems would be utilized for rural electrification and irrigation pumping.

Later, I understand that we will be hearing from officials from the DOD. I look forward to hearing their updated assessment of the photovoltaic market.

Also, my amendment calls for the DOD to submit a report to the House and Senate Committees on Armed Services as to the cost effectiveness of solar energy and other renewables to meet the DOD's energy needs. This report is due in October, and certainly I would be interested to hear what the DOD can tell us now about their findings.

Industry growth, innovation, promoting small business development, and the facilitation of early transition to sustaining markets are just a few of the benefits to be derived from my amendment.

By the Department of Defense taking the lead in utilizing promising alternative energy sources for military applications, the Pentagon's efforts will result not only in a reduction of its own consumption of petroleum products, but its experience and the accompanying technological spinoffs will be adaptable to the needs of the civilian world as well. This will assure a growing market for energy systems powered by solar and other renewable forms of energy and will hasten the general commercial, residential, industrial, agricultural, and governmental uses of such systems in the United States and abroad.

The need for the energy self-sufficiency provided by energy renewables, to my thinking, far outweighs any cost considerations involved. However, the beauty of the advanced state of development of these new energy technologies is that they are no more expensive today than the conventionally powered applications now in use. This is a point I would stress over and over again.

In fact, photovoltaic systems, over the past 25 years, have been shown to be highly reliable and workable energy resources. Photovoltaics today are meeting a number of military applications, including the provision of energy for remote communications, radar, weather sites, similar mobile units, perimeter security devices, navigational aids, and, of course, lighting, to name just a few.

Gone are the days when solar renewables were considered merely novel or an energy source for the future. I believe the future has arrived.

Finally, Mr. Chairman and members of the committee, we can no longer ignore the fact that we are forced to live beneath an energy ceiling. My amendment offers the DOD the opportunity to use its expertise, resources, and commitment to national security to guide this Nation to a high level of energy security and independence.

Thank you for the opportunity, Mr. Chairman.

[The prepared statement of Mr. Mavroules follows:]

NICHOLAS MAVROULES
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Statement by Congressman Nicholas Mavroules before the
Subcommittee on Energy Development and Applications, September 19, 1984

Mr. Chairman, I want to thank you for the opportunity to speak before you today, and for the privilege of joining my colleagues on this panel.

Your subcommittee has been addressing the issue of the viability of the photovoltaics industry. In the first day of testimony, several leaders in the field of photovoltaics spoke of the need to extend the energy tax credits. And they endorsed a policy of aggressive implementation of my 1983 amendment to the Military Construction Authorization Act. I appreciate their support and interest. Indeed, before and since enactment of that amendment, my office has been deluged with requests for information from energy companies across the country - most seeing this as a means of expanding their market.

For those here who are not completely familiar with my amendment, I would like to backtrack a moment and outline the reasons and purposes behind this measure.

The 1973 Arab oil embargo alerted all Americans, particularly the Defense Department, to the vulnerability of their dependence on petroleum products. But the military simply cannot afford to be immobilized by interruptions in supply lines that are dependent on a foreign nation's whims.

Cong. Mavroules
Page Two

The world has changed in these last eleven years, and we may never again be faced with a situation of the impact of the 1973 oil embargo, but neither should we wait around to see. The situation won't be getting any better. New oil discoveries will continue to be less than consumption and despite a reduction in oil consumption by the U.S., our allies are still very dependent on oil from foreign sources.

I think it behooves the Defense Department to support Congressional efforts to demonstrate to the American people not only the seriousness of our energy problems, but also what alternatives are available and can be stimulated by proper government action and policy.

Without the introduction of renewable forms of energy to the DOD's energy mix, I cannot see any improvement in the Department's status as the single, largest user of oil in the nation. Mainly because of the demand by aircraft and ships, some 81 percent of DOD's total energy needs must be met by petroleum products.

While developing innovative alternative energy sources to meet DOD's transportation needs may take more time, renewable energy sources can provide DOD today with an inexhaustible and reliable energy source for its electrical power generation needs.

My amendment, founded on the belief that energy security is national security, would ask the Secretary of Defense to play a greater role in reshaping the Department's own energy needs, and thus attain a higher level of military preparedness.

Cong. Mavroules
Page Three

It calls for the Department to procure energy systems powered by photovoltaics and other renewable forms of energy wherever cost-effective and applicable; and for the Department to use photovoltaics and other renewable forms of energy in new facilities, again wherever cost-effective and applicable, thereby making these facilities and installations relatively energy selfsufficient. I ask that a copy of my 1983 amendment be included in the record.

I recognize that some concerns were raised by earlier witnesses... that we cannot force any customer, whether it is the Department of Defense or a private company, to buy a product. That's true.

However, let me read for a moment from a study released by the DOD in 1977 that dealt with solar energy commercialization. This study, entitled "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analysis," stated that:

"Photovoltaics offer a number of advantages to the DOD. In addition to potential cost and fuel savings, photovoltaic energy systems would provide the DOD a highly reliable, silent power source allowing virtually unattended operation in most areas of the world. Near term benefits to the DOD include cost and logistics savings at remote sites, in portable equipment and offshore applications."

The report continues on to say:

"The U.S. would also receive national benefits from accelerated commercialization of photovoltaics. Over the longer term, photovoltaic energy systems will offer the nation a cost competitive source of commercial electric power, thus reducing dependence on foreign energy sources. Other national benefits include the development of exports to underdeveloped countries where photovoltaic systems would be utilized for rural electrification and irrigation pumping."

Later, I understand that we will be hearing from officials from the DOD. I look forward to hearing their updated assessment of the photovoltaic market, as it relates to our military.

• Cong. Mavroules
Page Four

Industry growth, innovation, promoting small business development and the facilitation of early transition to sustaining markets are just a few of the benefits to be derived from my amendment.

By the Department of Defense taking the lead in utilizing promising alternative energy sources for military applications, the Pentagon's efforts will result not only in a reduction of its own consumption of petroleum products, but its experience and the accompanying technological spinoffs will be adaptable to the needs of the civilian world as well. This will assure a growing market for energy systems powered by solar and other renewable forms of energy, and will hasten the general commercial, residential, industrial, agricultural and governmental uses of such systems in the U.S. and abroad.

The need for the energy self-sufficiency provided by energy renewables, to my thinking, far outweighs any cost considerations involved. But the beauty of the advanced state of development of these new energy technologies is that they are no more expensive today than the conventionally powered applications now in use. This is a point I would stress over and over again.

In fact, photovoltaic systems, over the past 25 years, have been shown to be highly reliable and workable energy resources. Photovoltaics today are meeting a number of military applications including the provision of energy for: remote communications, radar, weather sites, similar mobile units, perimeter security devices, navigational aids, and of course, lighting, to name just a few.

Gone are the days when solar renewables were considered merely novel or an energy source for the future. The future has arrived.

Cong. Mavroules
 . Page Five

We can no longer ignore the fact that we are forced to live beneath an energy ceiling. My amendment offers the DOD the opportunity to use its expertise, resources and commitment to national security to guide this Nation to a higher level of energy security and independence.

Thank You, Mr. Chairman.

Mr. FUQUA. Thank you, Nick.

Let me say that I want to commend you for not only your statement, but for your bill. I think, as you pointed out so very well in your statement, this is not a novel or a trinket for the Department of Defense to work with. It is here, and it can improve the industry considerably. By using it in many of the areas that you enumerated in your statement, it can not only aid the industry, but also it can make substantial contributions to national security and the many facets of needs that they have to which it is adaptable.

I want to commend you and say that you are, as always, on target and it is a very, very fine statement. I appreciate it very much.

Mr. MAVROULES. I thank you very much, Mr. Chairman.

Mr. FUQUA. We will be delighted to have you join us for the remainder of the hearing, and come on up and take your seat and act like you are back as a member of this committee because, as far as we are concerned, you still are.

Mr. MAVROULES. It is good to be back. Thank you, Mr. Chairman.

Mr. FUQUA. We are now pleased to hear from our colleague from the State of Oregon, Congressman Ron Wyden.

Ron, we are happy to have you here today and appreciate your statement before us today.

STATEMENT OF HON. RON WYDEN, A U.S. REPRESENTATIVE FROM THE STATE OF OREGON

Mr. WYDEN. Thank you very much, Mr. Chairman and colleagues.

I, too, want to praise you for organizing these hearings on the status of the photovoltaics industry in this country. In my view, this is a topic that is ripe for congressional review, and I would like to spend just a couple of minutes to provide my views on the importance of international marketing as a vehicle for enhancing our domestic photovoltaics energy industry.

Specifically, I would like to discuss what has been one of the most satisfying experiences I have had in the Congress, Mr. Chairman, and that is to have been the principal sponsor of the Renewable Energy Industry Development Act. That is legislation which just became law several months ago, and I think it is really going to help us turn around this situation that we have seen, and I think that your hearings highlight so well, that the United States

is simply falling behind our foreign competitors in promoting our own renewable energy industries.

I think the problem is not that the product is bad or that there aren't enough markets to reach. The problem is primarily one of organization, in particular, learning to capitalize on the opportunities that are out there in the marketplace.

In my view, to do that, we are going to have to have a new sense of cooperation between industry and Government. I think my legislation is going to help to promote that, and I think that without the cooperation, the United States is going to continue to face the prospect of literally being hustled out of its own game by better organized foreign competitors.

What we are seeing today as far as overseas marketing is that it is no longer a question of simply being technologically superior. Specifically, in this area, I think there is a consensus that we do hold a comfortable edge from the standpoint of technological superiority. However, today the problem is primarily one of aggressive marketing skills and investment policy.

Our competitors know this. We know it, too, but simply haven't chosen to act on this knowledge. So, in order to protect the market share that we now hold and reverse the decline in market shares that we are facing, we are going to have to turn around our policy and take steps to excel in marketing and investment strategies.

As your committee's prior hearings have revealed, close Government-industry cooperation is the norm rather than the exception among the competition. France and West Germany often fully fund participation of their domestic industry at overseas trade shows and missions. In addition, these nations fully fund and install initial demonstration projects in a country, knowing that they would be in a preferred position for receiving future orders. For example, Australia subsidizes up to 70 percent of a firm's export related expenses.

These couple of examples are by no means an exhaustive review, but I think they illustrate that it is plain to see, by the activities of our competitors, that Government and industry need to begin fostering an aggressive trade policy if we are going to capitalize on this growing market.

It is my view that we don't necessarily need some kind of master organizational plan similar to what the Japanese have or, for example, that we need to emulate the subsidy practices of some of our competitors. In fact, I believe that those in the renewable energy industry state that they don't need additional financing or big, brassy, new expensive programs, but would rather see Government and industry cooperate to find ways to strengthen the programs that already exist.

In operation, what an aggressive trade policy would mean in this area would be to relay overseas opportunities and marketing information to American firms as well as insuring that overseas officials are knowledgeable of the U.S. industry and its capabilities. It would also mean exploring new opportunities for our export assistance agencies to provide medium-term and medium-range loans and other forms of export assistance. Most of the export sales the industry puts together are in the area of \$100,000 to \$750,000,

rarely over the \$1 million threshold that most U.S. agencies provide assistance for.

These are just some of the highlights of what I think an aggressive trade policy might consist of in the area of the renewable energy industry field. As I said, several weeks ago, H.R. 3169 was signed into law, and it was a very satisfying experience for me to have introduced the legislation and helped to move it through the Congress. The law forms a basis for the comprehensive marketing strategy we need to compete effectively, and it is a strategy that doesn't distort the free marketplace system or violate international trade agreements.

What the legislation calls for is the appointment of an interagency working group, composed of relevant agency heads and representative industries and chaired by the Secretary of Energy, to develop and implement a strategy for improving the ability of U.S. renewable energy companies to market overseas.

I have been very pleased, Mr. Chairman, and colleagues on both sides of the aisle, by the initial response of the administration on this issue. Mr. Hodel has made very favorable comments. I have been very pleased with Undersecretary Collins as well in his energy and his initiative in implementing this law in the first few months since it has been signed.

Last week, the first formal event under the law took place. DOE sponsored a Government-photovoltaic industry forum on export assistance. The forum provided business and Government the opportunity to engage in a frank and complete exchange of views on how they can work better together.

I also understand that later this year, the first formal meeting of the interagency working group will convene. So, DOE and Commerce do appear to be moving forward aggressively. Frankly, I would say to my colleagues, it is refreshing to see them go about it in such an aggressive and forthright way. It really stands as quite a contrast to the way some agencies go about in Washington, DC to implement the laws of the land.

Finally, Mr. Chairman, I would just say in summary that it is clear that the overseas markets are absolutely vital to the health of the domestic renewable energy industry and that the international competition is fierce, and it is going to get even fiercer. So, there is plenty of room for our industries in this area to grow overseas. I think it is the job of us in Government to help grease the skids for this private sector growth. To do that, we are going to have to take some direct steps to forge a new partnership between Government and private industry.

I am hopeful that our legislation moves us dramatically in that direction. I am sure there are other things that the committee is going to look for in the days ahead. I think it is a combination, really, of getting organized and getting tough. I am thoroughly convinced that if we combine the strength of our Government with the imagination and the initiative of those in the private sector, we are not going to have any trouble in tapping these new and very lucrative markets for renewable energy overseas.

I very much appreciate the opportunity, Mr. Chairman and colleagues, to be able to come to the subcommittee and address this topic, and I commend you for all your efforts.

[The prepared statement of Mr. Wyden follows:]

Congressman Ron Wyden
 September 19, 1984
 Photovoltaics Hearing

THE U.S. PHOTOVOLTAICS INDUSTRY IN INTERNATIONAL MARKETS

Mr. Chairman, I commend you for organizing these hearings on the status of the photovoltaics industry in America. It is a topic ripe for congressional review. I would like to take this opportunity to provide my views on the importance of international marketing as a vehicle for enhancing our domestic photovoltaics energy industry.

I would also like to discuss the progress government and industry will make under the aegis of the Renewable Energy Industry Development Act, that became law several months ago.

The problem is simply that the United States is falling behind our foreign competitors in promoting our own renewable energy industry. It's not that the product is bad or that there aren't enough markets to reach — the problem is one of organization and learning to capitalize on the opportunities that are out there. That will take cooperation between industry and government.

Without that cooperation, the U.S. faces the prospect of being hustled out of its own game by better organized foreign competitors.

The key to successful overseas marketing today is no longer simple technological superiority. In that regard, we hold a comfortable edge.

Rather, the keys are aggressive marketing skills and investment policies. Our competitors know this. We know it too but have not chosen to act on the knowledge.

In order to protect the market share we now hold and reverse the decline in market shares we are facing, we must excel in marketing and investment strategies.

As your Committee's prior hearings have revealed, close government/industry cooperation is the norm rather than the exception among our competitors.

France and West Germany often fully fund participation of their domestic industry at overseas trade shows and missions.

In addition, these nations fully fund and install initial demonstration projects in a country, knowing that they will be in a preferred position for receiving future orders.

Australia subsidizes up to 70 percent of a firm's export-related expenses.

These examples are by no means an exhaustive review.

I think it is plain to see by the activities of our competitors that government and industry need to begin fostering an aggressive trade policy if we expect to capitalize on the growing renewable energy market.

This is not to say that we need a master organization similar to Japan's MITI, or that we have to emulate the subsidy practices of our competitors.

In fact, I believe those in the industry will state that they do not need additional financing or new programs, but would rather see government and industry cooperate to find new ways to strengthen programs that already exist.

In short we need an aggressive trade policy in this area, whose cornerstone is a mutually beneficial government-industry relationship.

In operation, that policy would mean relaying overseas opportunities and marketing information to American firms, as well as ensuring that overseas officials are knowledgeable of the U.S. industry and its capabilities.

It would also mean exploring new opportunities for our export assistance agencies to provide medium-term and medium-range loans and other forms of export assistance. Most of the export sales the industry puts together are in the \$100,000- \$750,000 range, rarely over the million dollar threshold most US agencies provide assistance for.

These are just some of the highlights of what I see as an aggressive trade policy.

Congress recently took steps to affect such a policy. Several weeks ago, HR 3169 introduced by myself and Congressman Heftel, was signed into law. The law forms a basis for the comprehensive marketing strategy we need to compete effectively -- a strategy that does not distort free market competition or violate international trade agreements.

The Renewable Energy Development Act of 1983 calls for the appointment of an interagency working group -- composed of relevant agency heads and representative industries and chaired by the Secretary of Energy -- to develop and implement a strategy for improving the ability of US renewable energy companies to market overseas.

I am very encouraged by the leadership the Department of Energy, particularly Undersecretary Collins has exhibited in implementing this law.

Last week, the first formal event under the law took place. The DOE sponsored a government/photovoltaic industry forum on export assistance. The forum provided business and government the opportunity to engage in a frank exchange of views on how they can work better together.

I also understand that later this year the first formal meeting of the interagency working group will convene. In short, DOE and Commerce appear to be moving forward aggressively. It is a refreshing change from the way some agencies go about implementing the laws of the land.

To summarize Mr. Chairman, it is clear that our overseas markets are vital to the health of our domestic industry, and that international competition is fierce.

There is plenty of room for our renewable energy industry to grow overseas. And if we in government can help grease the skids for this growth, then we should take the steps to forge that partnership.

The Renewable Energy Industry Development Act coherently addresses government/industry coordination, and, I hope, will help attain the common goal of increased international sales.

To meet and beat the competition we have to get organized and get tough. I'm thoroughly convinced that if we combine the strength of our government with the imagination and ambition of our industry we will have no trouble achieving that task.

I appreciate the opportunity to address this important topic.

Mr. BOUCHER [acting chairman]. Thank you, Mr. Wyden, for your very thoughtful, well prepared, and well presented statement. I am sure that your remarks here are going to be very helpful to us as we continue our deliberations.

I appreciate your being with us.

Mr. WYDEN. Thank you very much.

Mr. BOUCHER. Now, I would recognize panel No. 2 and ask each of these individuals to come forward to the table: Mr. Sam Enfield from the Export Council for Renewable Energy, Mr. Clyde Ragsdale from Solavolt International, and Mr. Scott Sklar from the Solar Energy Industries Association.

We are glad to have you with us today. We will call on Mr. Enfield for his statement at this time.

STATEMENT OF SAM ENFIELD, EXPORT COUNCIL FOR RENEWABLE ENERGY, WASHINGTON, DC

Mr. ENFIELD. Thank you, Mr. Chairman.

I want to thank the subcommittee for extending to me the opportunity of appearing here today. I also want to thank the subcommittee for its interest in the area. As I recall, it was this subcommittee which first picked up on the idea of using the Department of Energy resources to assist the participation of renewable energy funds in the trade promotion activities of the Department of Commerce.

This has been an extremely effective vehicle for the industry in a lot of ways. It has also been an excellent example of how two different agencies with very different capabilities can collaborate effectively for the benefit of a young industry facing difficult challenges in its development. I think it will serve well as a model for the interagency working group on international renewable energy development which was authorized under the Wyden Act this year and is being implemented by the Department of Energy.

One of the principal advantages that the interagency working group should have for the industry is offering greater coordination and leveraging of resources among the various and numerous Federal programs that can affect the export of photovoltaics. What we are hoping for is that the overall effectiveness of the group will be greater than the sum of the capabilities of the individual programs and agencies that are participating in it.

We have all heard for some time about the support that foreign governments provide to their renewable energy industries. In order to understand the situation better, the Export Council has been conducting a study of these activities for the Department of Commerce. This work will be completed within a month, and I will be pleased to provide a copy of it to the subcommittee.

One of our principal findings will be, I believe, that it is the coordination of Government programs in support of an industry's development that is critical rather than simply the support of various discrete programs addressing separate and individual functions. Fewer organizations are involved in the administration of programs overseas, which obviously makes coordination easier.

In fairness to ourselves, I think, because of our sheer size and the volume of funds we administer in this area and the number of com-

panies we are trying to serve, simply consolidating programs within one agency may not necessarily improve coordination. Perhaps it is wisest to coordinate less formally or rigidly and allow the industry, which is, after all, the common denominator and the focus of the effort, to provide the opportunities around which coordination can occur.

I think that the interagency working group is an ideal mechanism for this approach, and I look forward to helping the industry use it in that way. I might add that from what I have seen so far, the enthusiasm is there at the Department of Energy for making the group a success in just this way.

I was asked by the subcommittee to address specifically the adequacy of Government incentives for export sales by the U.S. photovoltaics industry, so I shall discuss a few of the programs that we have at our disposal.

In the area of international market development, it has been consistently industry's view that one of the most critical roles that government can play is in helping bring industry members into direct contact with prospective overseas customers and partners. This subcommittee, as I mentioned before, responded to this by helping to establish, in 1982, a program under which DOE resources are made available to assist the participation of U.S. renewable energy firms in the export promotion programs of the Department of Commerce.

The International Trade Administration, ITA, of the Department of Commerce sponsors industry missions of either commercial or technical natures to selected nations where meetings are arranged with key public and private sector individuals. ITA also organizes U.S. industry pavilions at overseas trade fairs and catalogue shows of U.S. products.

One other important activity in this area is that ITA has recruited key foreign public and private sector individuals for attendance at domestic trade fairs, including three renewable energy trade fairs. This program is conducted for most U.S. industries on a full cost recovery basis. I think if this condition applied to the renewable energy industry, participation in it would be substantially lower. The DOE provided assistance usually offsets about half the cost of the admission and is of significant help.

The only other program of potentially comparable value to the industry is one that was conducted on a rather limited basis by the Agency for International Development. In this activity, groups of industry representatives were taken to selected developing countries for meetings with potential project developers and joint venture partners. All costs were picked up by AID. From what I understand, these were successful events. I would hope that AID might resuscitate that program. Dr. Jack Vander of AID's Office of Energy Resources mentioned at last week's export seminar that that was, in fact, being considered.

In the area of feasibility assessment, there are a number of programs that assist in the financing of feasibility studies of either transactions, projects, or overseas joint ventures. Almost all of these are conducted on a cost-shared basis through reimbursible grants which are required to be repaid only if the venture proceeds.

These appear to be attractive programs to establish industries. However, 50 to 60 percent of the cost of a feasibility study, costing in total between \$50,000 and \$100,000, is a substantial expense for a small company on a division in an emerging industry. I would recommend that the subcommittee explore the possibility of assisting the Department of Energy in providing the company's share of the expense of the feasibility study, perhaps from a revolving fund that might also be reimbursed if the venture proceeds.

The feasibility assessment phase of project development is particularly critical in that the specifications written into the project design often are tailored to products from the designer's own company or country. This makes it much more difficult to participate in a project if the study is funded and performed by a foreign company.

There are other constraints which limit the usefulness of the trade and development program's feasibility study program for the U.S. PV industry. The program guidelines specify that funding for feasibility study is available only if the total value of the U.S. exports likely to result from it are worth 75 to 100 times the cost of the study. This, plus the fact that the severe staff constraints of the program constrict the number of applications that can be handled which, in turn, encourages staff to concentrate on fewer numbers of projects and, I believe, restricts access to the program funding for smaller businesses. I would strongly recommend that the Department of Energy be encouraged to find ways to provide technical support to the trade and development program staff to permit it to more easily process feasibility study applications in the PV and other renewable energy fields.

The commercial export transaction financing program of the United States, the Export-Import Bank, is governed with respect to the interest rates it can offer to U.S. exporters by the formal arrangement of the Organization of Economic Cooperation and Development, OECD. U.S. commercial export financing rates, like those of all of the signatories to the arrangement, are tied to the prevailing domestic commercial interest rates. Strict adherence to this arrangement is the policy of the Federal Government. The result of this situation is that the Japanese, West German, and Dutch exporters, whose countries' commercial interest rates are significantly lower than those of the United States and the other OECD members, enjoy commercial export advantages.

Exim is willing to depart from this standard only in the event that a U.S. exporter faces mixed credit financing made available to a foreign competitor by its government. Mixed credits occur when foreign assistance funds are blended with commercial finance to bring down the overall interest rate of the package. On three recent occasions, Exim has offered to finance transactions at highly concessional rates which were set to precisely meet the conditions offered through foreign mixed credit packages. None of these mixed credit offerings, however, have occurred in the renewable energy field.

The Exim programs for medium-term financing, which is anywhere from 6 months to 5 years, consist of guarantees on commercial loans to exporters and can have the effect of making available commercial financing at as much as a full percentage point below

what would be offered in their absence which is significant to any U.S. exporter. But it is interesting to note that use of the Exim programs by the PV industry has been very limited, really consisting only of one transaction.

The final aspect of the financing issue that I want to address today is the area of development assistance. It is in this area that the photovoltaics industry's greatest involvement with overseas Government financing has occurred and in which I believe the greatest near-term potential still exists. I use the term financing somewhat loosely here, for export financing is not the stated purpose of the U.S. Government's foreign assistance agency, the Agency for International Development.

AID's mandate is to stimulate economic development in the less developed world. Exports of U.S. products or technology are, and in all likelihood always will be, secondary to that mission. Helping its clients to develop alternatives to imported oil as an energy source is central to AID's mission, and this has brought its attention to photovoltaics and other renewable energy technologies.

The AID Office of Energy has supported demonstrations but with very mixed success. My impression is that this demonstration program suffered from problems experienced in domestic demonstration programs as well, in that technologies which were not commercially ready but upon which high expectations were placed experienced operational problems and high system cost. The result has been a widespread disenchantment with photovoltaics within AID and this is going to be difficult to overcome, I believe.

Some AID country missions, and it is the country missions which actually control the bulk of the Agency's funding resources, have supported photovoltaic purchases by their clients. Many of the more recent of these are operating very successfully. AID is currently organizing an effort to document the performance of these systems in order to assist its country officials in understanding better the performance of photovoltaics. However, I think it is clear at this point that wider support for photovoltaics within the agency will await that sort of reeducation process.

This whole area is an appropriate situation for this subcommittee's attention, experienced as it is in the development of technologies and in the dissemination of information about them. It is also appropriate for the Department of Energy, and the Department appears to be committed to helping AID update its information on photovoltaics and other renewable energy technologies. That is principally going to occur, from what I understand, through a greatly expanded technology transfer program which will be, I think, valuable for AID as well as the rest of the internationally oriented programs. I would urge the committee to strongly support the Department in the expansion of its technology transfer program.

There is one other reason, other than stimulating direct procurements from AID client nations, to help AID realize the commercial viability of photovoltaics. A growing focus of AID's economic development mission is the facilitation of joint venture agreements between U.S. and client nation businesses.

There is growing interest among developing nations in participating in the economic benefits of product manufacture. "Local

content" is the term of art most often used to describe this objective. A number of U.S. PV manufacturers are basing, at least in part, their marketing strategies in meeting this interest, and we have found in our study of the renewable energy programs of our foreign competitors that this type of joint venture marketing strategy is widely perceived by foreign companies to be the most effective way to establish sustainable, competitive positions in international markets.

It remains to be seen how much of the production or assembly process can or should be transferred to market nations, but if, in fact, this trend is significant, then directing the interest of AID toward assisting the formation of overseas joint ventures in photovoltaic and other renewable energy technologies will be extremely valuable.

Mr. Chairman, I want to thank you again for the opportunity of addressing these issues today and say that I will certainly be happy to work with your staff in pursuing any of the individual issues further.

[The prepared statement of Mr. Enfield follows:]

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TESTIMONY

OF MR. SAMUEL E. ENFIELD, EXECUTIVE DIRECTOR

UNITED STATES EXPORT COUNCIL FOR RENEWABLE ENERGY

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

SEPTEMBER 19, 1984

MR. CHAIRMAN, THANK YOU FOR THE OPPORTUNITY OF APPEARING HERE TODAY TO DISCUSS THE INTERNATIONAL MARKETING PROSPECTS OF THE U. S. PHOTOVOLTAIC INDUSTRY. I ALSO WANT TO THANK THE SUB-COMMITTEE FOR ITS CONTINUED INTEREST IN AND SUPPORT FOR THE DEVELOPMENT OF THE U. S. PHOTOVOLTAIC INDUSTRY, AND OF THE U. S. RENEWABLE ENERGY SECTOR OVERALL.

THE UNITED STATES EXPORT COUNCIL FOR RENEWABLE ENERGY WAS FOUNDED IN 1982, TO REPRESENT THE INTERNATIONAL MARKETING INTERESTS OF THE U. S. RENEWABLE ENERGY SECTOR. US-ECRE INCLUDES AMONG ITS MEMBERSHIP THE TEN LEADING RENEWABLE ENERGY INDUSTRY, POLICY AND TECHNICAL ORGANIZATIONS IN THIS COUNTRY. I HAVE SERVED, SINCE LATE 1983 AS THE COUNCIL'S FIRST EXECUTIVE DIRECTOR. PREVIOUS TO THAT, WHILE ON THE STAFF OF THE SOLAR LOBBY, I PROVIDED STAFF SUPPORT TO THE COUNCIL AND WORKED TO ESTABLISH PROGRAMS IN SUPPORT OF THE INDUSTRY'S EXPORT EFFORTS.

THE INTERNATIONAL MARKETING OF PHOTOVOLTAICS MIGHT APPEAR, ON THE FACE OF IT, TO BE MORE APPROPRIATELY ADDRESSED IN CONGRESS BY COMMITTEES INVOLVED DIRECTLY IN INTERNATIONAL TRADE AND DEVELOPMENT. THOSE ARE, IN FACT, AUDIENCES WHICH US-ECRE IS WORKING TO REACH. THE MANDATE OF THE SCIENCE AND TECHNOLOGY COMMITTEE, HOWEVER - TECHNOLOGY DEVELOPMENT AND, PERHAPS MORE IMPORTANTLY IN THIS CASE, DISSEMINATION - ARE VERY RELEVANT TO

THE NEEDS OF THE U. S. PHOTOVOLTAIC INDUSTRY IN ITS EFFORTS TO DEVELOP INTERNATIONAL MARKETS. FOR THAT REASON, I ESPECIALLY WELCOME THIS OPPORTUNITY.

THE FEDERAL GOVERNMENT HAS, AS THIS SUBCOMMITTEE WELL KNOWS, SPENT SEVERAL YEARS AND SEVERAL HUNDRED MILLION DOLLARS ON THE RESEARCH AND DEVELOPMENT OF PHOTOVOLTAIC TECHNOLOGIES AND SYSTEMS. THIS EFFORT HAS COVERED THE PHOTOVOLTAIC EFFECT ITSELF, MATERIALS RESEARCH, CELL PRODUCTION TECHNOLOGY AND SYSTEMS AND MARKET DEVELOPMENT. IT HAS BEEN AIDED BY THE EXISTENCE OF THE ENERGY TAX CREDITS FOR BOTH RESIDENTIAL AND COMMERCIAL APPLICATIONS OF PHOTOVOLTAICS, AND BY THE PUBLIC UTILITY REGULATORY POLICIES ACT (PURPA) OF 1978, WHICH GUARANTEES ACCESS TO UTILITY GRIDS FOR PHOTOVOLTAIC SYSTEMS AND FAIR PAYMENT FOR THE POWER THEY PROVIDE.

THE TECHNOLOGY DEVELOPMENT EFFORT HAS ALMOST EXCLUSIVELY BEEN CONDUCTED THROUGH THE DEPARTMENT OF ENERGY, WITH THE RESULT THAT A VERY EFFECTIVE WORKING RELATIONSHIP EXISTS BETWEEN THAT AGENCY AND THE U. S. PHOTOVOLTAIC INDUSTRY. AS COST EFFECTIVE APPLICATIONS OF PHOTOVOLTAICS HAVE EMERGED, HOWEVER, FAMILIARITY WITH THEM AMONG OTHER FEDERAL PROGRAMS HAS BECOME IMPORTANT. WHAT HAS OCCURRED, HOWEVER - AND UNFORTUNATELY FOR THE U. S. PHOTOVOLTAIC INDUSTRY AND OTHER RENEWABLE ENERGY INDUSTRIES IN A SIMILAR SITUATION - IS THAT THE DEPARTMENT OF ENERGY'S PROGRAM

WAS REORIENTED AWAY FROM COMMERCIALLY DIRECTED ACTIVITIES SUCH AS TECHNOLOGY TRANSFER JUST AT THE POINT IN THE INDUSTRY'S DEVELOPMENT THAT THEY BECAME MOST APPROPRIATE. I MIGHT ADD PARENTHETICALLY AT THIS POINT THAT THE CURRENT LEADERSHIP AT THE DEPARTMENT HAS REVERSED THIS TREND, A FACT WHICH NO DOUBT HEARTENS US ALL.

THE RESULT, THEN, OF THE EVENTS IN 1981 AND 1982 WAS THAT AN INDUSTRY STILL HEAVILY INVOLVED IN PRODUCT DEVELOPMENT AND LACKING A SIGNIFICANT SALES BASE WAS ABRUPTLY FORCED TO ASSUME A MUCH GREATER SHARE, IF NOT ALL, OF ITS COMMERCIALIZATION EXPENSES. THE INTRODUCTION OF NEW PRODUCTS TO POTENTIAL USERS AND THE ESTABLISHMENT OF MARKETING AND SALES NETWORKS ARE CRITICAL BUT COSTLY STAGES IN THE DEVELOPMENT OF ANY INDUSTRY, PARTICULARLY ONE SUCH AS THE PHOTOVOLTAIC INDUSTRY THAT IS CHARACTERIZED BY SMALL COMPANIES OR SMALL DIVISIONS OF LARGER COMPANIES WITH VERY REAL CAPITAL CONSTRAINTS. THE PHOTOVOLTAIC INDUSTRY MAY HAVE SUFFERED EVEN MORE IN THIS REGARD THAN OTHER RENEWABLE ENERGY INDUSTRIES IN THAT IT HAS CONSISTENTLY RELIED ON OVERSEAS MARKETS FOR APPROXIMATELY HALF OF ITS SALES, AND THE INTERNATIONAL MARKET IS NOTORIOUSLY EXPENSIVE AND TIME CONSUMING TO DEVELOP.

THE INTERNATIONAL MARKET FOR PHOTOVOLTAICS IS NOT A

DISINTERESTED ONE. AWARENESS AND ANTICIPATION OF THE TECHNOLOGY IS CONSIDERABLE IN MANY AREAS. BUT THE COST OF PHOTOVOLTAICS AND THEIR RELATIVE CAPITAL INTENSIVENESS - THE FACT THAT IS ONLY TOO WELL KNOWN BY THE PEOPLE IN THIS ROOM THAT VIRTUALLY ALL OF THE LIFETIME COST OF A PHOTOVOLTAIC SYSTEM OCCURS IN THE INITIAL PURCHASE AND INSTALLATION PRICE - IS FRUSTRATING THE INDUSTRY'S ABILITY TO MOVE BEYOND SPECIALTY APPLICATIONS AMONG OTHER MATURE AND WELL CAPITALIZED INDUSTRIES (I. E. TELECOMMUNICATIONS) AND INTO LARGER SCALE AND MORE BROADLY BASED APPLICATIONS REPRESENTING LARGER MARKETS. THE INABILITY OF OVERSEAS AGRICULTURAL AND RURAL DEVELOPMENT SECTORS TO AFFORD THE CAPITAL COSTS OF PHOTOVOLTAICS IS IMPEDING THEIR WIDESPREAD USE IN SUCH APPLICATIONS AS IRRIGATION AND THE PROVISION OF ELECTRIC POWER TO SOCIALLY REMOTE COMMUNITIES.

THUS THE GREATEST SINGLE ISSUE CONFRONTING THE U. S. PHOTOVOLTAICS INDUSTRY IN ITS INTERNATIONAL MARKETING EFFORTS IS FINANCING, BOTH AS IT RELATES TO THE INDUSTRY'S ABILITY TO IDENTIFY AND DEVELOP OVERALL MARKETS AND SPECIFIC APPLICATIONS AND AS IT RELATES TO THE ABILITY OF POTENTIAL CUSTOMERS TO PAY FOR THE SYSTEMS.

THE INDUSTRY'S ABILITY TO MAKE THE TRANSITION TO THE NEXT PHASE OF ITS INTERNATIONAL MARKETING IS COMPLICATED EVEN FURTHER

BY THE FACT THAT IT NOW FACES VERY STIFF COMPETITION FROM INDUSTRIES IN A NUMBER OF FOREIGN COUNTRIES. MOST NOTABLE IN THIS REGARD IS JAPAN. BASED IN LARGE PART ON WORK PIONEERED IN THIS COUNTRY, BUT NOW BACKED BY GOVERNMENT R&D SUPPORT FOCUSED ON THE DEVELOPMENT OF COMMERCIAL APPLICATIONS, INDUSTRIES HAVE DEVELOPED THAT MATCH INCREASINGLY COMPETITIVE TECHNOLOGIES WITH ALREADY COMPETITIVE MARKETING STRATEGIES. THIS SUBCOMMITTEE HAS ALREADY HEARD STATISTICS ON THE REDUCTION OF WORLD MARKET SHARE MET BY THE U. S. PHOTOVOLTAIC INDUSTRY, FIGURES UPON WHICH I CANNOT IMPROVE. WHILE I FEEL THAT SOME REDUCTION IN OUR MARKET SHARE IS INEVITABLE, CONSIDERING THE RECENT DEVELOPMENT OF OVERSEAS COMPETITION, I AM ALARMED AT THE PROSPECT THAT THE U. S. MAY FAIL TO CAPITALIZE ADEQUATELY ON THE OPPORTUNITY THAT PHOTOVOLTAICS HAVE PROVIDED US AS AN EXPORT PRODUCT OF TREMENDOUS POTENTIAL. THERE IS REAL URGENCY IN MOBILIZING OUR PUBLIC AND PRIVATE SECTOR EXPORT SUPPORT SERVICES ON BEHALF OF THE PHOTOVOLTAIC INDUSTRY BEFORE ANY MORE GROUND IS LOST TO OUR COMPETITION.

I HAVE REFERRED TO PUBLIC AND PRIVATE SECTOR TRADE SERVICES SIMULTANEOUSLY BECAUSE PUBLIC SECTOR INVOLVEMENT IN INTERNATIONAL TRADE IS UNAVOIDABLE AND, IN FACT, IRREPLACEABLE. INTERNATIONAL TRADE, FAR MORE THAN DOMESTIC TRADE, IS CONDUCTED UNDER THE SCRUTINY OF GOVERNMENTS. INTERNATIONAL RELATIONS IN GENERAL AND INTERNATIONAL TRADE AGREEMENTS IN PARTICULAR AFFECT THE ACCESS OF

INDUSTRIES TO PARTICULAR MARKETS, THE AVAILABILITY AND TYPES OF FINANCING IN SUPPORT OF INTERNATIONAL TRANSACTIONS AND EVEN THE ABILITY TO EXPORT CERTAIN PRODUCTS OR SERVICES. THE FIRST TWO OF THESE CONSIDERATIONS ARE PARTICULARLY RELEVANT TO PHOTOVOLTAIC TRANSACTIONS. THE ERECTION OF IMPORT BARRIERS BY VARIOUS NATIONS IS COMPLICATING TRADE IN A NUMBER OF INDUSTRY AREAS, AND U. S. PHOTOVOLTAIC MARKETERS MUST BE CONCERNED WITH ESTABLISHING POSITIONS IN OVERSEAS MARKETS THAT CAN SURVIVE THE ERECTION OF UNILATERAL IMPORT BARRIERS. FINANCING OF PHOTOVOLTAIC EXPORTS - IN ANY FORM - ARE PARTICULARLY DEPENDANT ON INTERNATIONAL TRADE AND DEVELOPMENT POLICY BECAUSE THE ABILITY OF FOREIGN CUSTOMERS TO AFFORD PHOTOVOLTAICS IS SO DEPENDANT ON GOVERNMENTALLY PROVIDED OR UNDERWRITTEN FINANCIAL SUPPORT. EVEN EXPORT LICENSING PROCEDURES, DESIGNED TO PROTECT AGAINST THE LOSS TO ADVERSARIAL NATIONS OF STRATEGICALLY IMPORTANT TECHNOLOGY, HAS AFFECTED - THOUGH NOT SERIOUSLY OBSTRUCTED - THE EXPORT OF PHOTOVOLTAIC EQUIPMENT.

SUCCESSFUL U. S. EXPORTERS HAVE TRADITIONALLY MADE GOOD USE OF THE U. S. TRADE POLICY PROCESS IN THEIR INTERNATIONAL MARKETING ACTIVITIES. THESE HAVE BEEN RELATIVELY FEW IN NUMBER, HOWEVER, AND USUALLY HAVE BEEN VERY LARGE COMPANIES MARKETING BIG TICKET PRODUCTS OR PROJECTS OR LARGE VOLUMES OF SPECIALTY EQUIPMENT. ONLY RECENTLY HAVE U. S. BUSINESSES IN GREATER NUMBERS AND MORE

VARYING SIZES BEGUN SERIOUSLY ADDRESSING THE EXPORT MARKET. THERE REMAINS AMONG U. S. BUSINESSES, HOWEVER, A LACK OF FAMILIARITY WITH THE INTERNATIONAL TRADE SECTOR IN GENERAL AND THE U. S. GOVERNMENT'S TRADE SUPPORT SERVICES IN PARTICULAR. THIS UNFAMILIARITY IS BUT ONE MORE COMPLICATION FOR SOME U. S. PHOTOVOLTAIC MANUFACTURERS IN THEIR EFFORTS TO DEVELOP OVERSEAS MARKETS.

FOREIGN INDUSTRIES ARE, AS A RULE, MUCH MORE EXPERIENCED INTERNATIONALLY AND MUCH MORE ASSERTIVE AND AGGRESSIVE AT USING THEIR GOVERNMENTS TO SUPPORT THEIR EXPORT EFFORTS. THIS HAS EMERGED AS A CENTRAL FINDING OF A STUDY NOW BEING CONDUCTED BY MY ORGANIZATION FOR THE DEPARTMENT OF COMMERCE ON THE EFFECTS OF GOVERNMENTAL POLICY ON BEHALF OF RENEWABLE ENERGY DEVELOPMENT AND INTERNATIONAL MARKETING. WITHOUT EXCEPTION AMONG THE FIVE COMPETITORS TO THE U. S. IN RENEWABLE ENERGY THAT WE ARE EXAMINING - JAPAN, WEST GERMANY, FRANCE, DENMARK AND ISRAEL - GOVERNMENT PROGRAMS FROM THE RESEARCH AND DEVELOPMENT PHASE ON THROUGH TO THE EXPORT ASSISTANCE PHASE ARE TAILORED TO ASSIST INDUSTRY IN ACHIEVING COMPETITIVE POSITIONS IN FOREIGN MARKETS AND ARE IMPLEMENTED IN CLOSE CONJUNCTION WITH THOSE INDUSTRIES.

THIS IS NOT TO SAY THAT THE U. S. LACKS GOVERNMENT PROGRAMS TO ASSIST OUR INDUSTRIES' EXPORT EFFORTS. TO THE CONTRARY, THERE

IS AN IMPRESSIVE ARRAY OF PROGRAMS AVAILABLE TO U. S. INDUSTRY FOR THAT PURPOSE. SOME IMPROVEMENTS MIGHT BE MADE IN THEM TO BE SURE, PARTICULARLY WITH RESPECT TO THEIR ABILITY TO SERVE THE PHOTOVOLTAIC INDUSTRY. I SHALL OFFER SOME SUGGESTIONS PRESENTLY. HOWEVER, THE CRITICAL DIFFERENCES APPEAR TO ME TO BE THAT FOREIGN INDUSTRIES ARE FAR MORE COMFORTABLE DEALING IN A PARTNERSHIP FRAMEWORK WITH THEIR GOVERNMENTS, AND THAT THOSE GOVERNMENT PROGRAMS ARE MORE CLOSELY INTEGRATED AND THUS MORE ACCESSIBLE TO INDUSTRY AND MORE EFFECTIVE ON INDUSTRY'S BEHALF.

IN EACH OF THESE AREAS I SEE ROOM FOR OPTIMISM WITH RESPECT TO U. S. PHOTOVOLTAIC EXPORTS. THE U. S. PHOTOVOLTAIC INDUSTRY, AS I STATED EARLIER, ENJOYS A VERY PRODUCTIVE RELATIONSHIP WITH THE FEDERAL GOVERNMENT THROUGH THE DEPARTMENT OF ENERGY, AND OUGHT TO COME FAR MORE EASILY THAN MOST U. S. INDUSTRIES TO DEALING EFFECTIVELY WITH THE GOVERNMENT'S TRADE PROGRAMS. IN FACT, THE DEPARTMENT OF ENERGY ITSELF IS NOW IN A POSITION TO HELP DEVELOP THOSE RELATIONSHIPS THROUGH ITS LEAD POSITION ON THE INTERAGENCY WORKING GROUP ON INTERNATIONAL RENEWABLE ENERGY DEVELOPMENT, ESTABLISHED THIS YEAR UNDER THE WYDEN ACT (P. L. 98-370). FURTHERMORE, THE INTERAGENCY WORKING GROUP OFFERS THE OPPORTUNITY TO ADD A MUCH NEEDED, HEIGHTENED DEGREE OF COORDINATION AMONG THE INTERNATIONAL PROGRAMS, AND ENHANCE THEIR OVERALL EFFECTIVENESS ON BEHALF OF THE PHOTOVOLTAIC AND OTHER RENEWABLE ENERGY INDUSTRIES.

I AM GREATLY ENCOURAGED BY THE ENTHUSIASM EVIDENCED AT THE HIGHEST LEVELS OF THE DEPARTMENT OF ENERGY FOR THIS TASK. IT WILL BE NEEDED. THE U. S. EXPORT COUNCIL FOR RENEWABLE ENERGY, FOR ITS PART, WILL CERTAINLY DO WHATEVER IT CAN TO EFFECTIVELY REPRESENT INDUSTRY'S INTERESTS BEFORE THE GROUP, TO ASSIST THE DEPARTMENT OF ENERGY AND OTHER MEMBER AGENCIES IN ITS IMPLEMENTATION AND TO HELP OVERALL TO MAKE IT A SUCCESS.

MR CHAIRMAN, I HAVE BEEN ASKED TO SPECIFICALLY ADDRESS THE QUESTION OF THE ADEQUACY OF GOVERNMENT INCENTIVES FOR EXPORT SALES BY THE U. S. PHOTOVOLTAIC INDUSTRY. I AM ASSUMING THAT THAT REFERS TO FINANCIAL SUPPORT FOR THE RANGE OF EXPORT ORIENTED ACTIVITIES THAT INCLUDES MARKET DEVELOPMENT, FEASIBILITY ASSESSMENT, TRANSACTION FINANCING AND INVESTMENT SUPPORT.

THE U. S. GOVERNMENT DOES OFFER PROGRAMS THAT ADDRESS EACH OF THESE PHASES OF INTERNATIONAL MARKETING. HOWEVER, THEIR EFFECTIVENESS, PARTICULARLY WITH RESPECT TO SUPPORTING PHOTOVOLTAIC EXPORTS, VARIES.

FOR SPECIFIC INFORMATION ON THE SERVICES OFFERED BY THESE PROGRAMS, I WOULD REFER THE SUBCOMMITTEE TO THE GUIDE TO "FEDERAL EXPORT ASSISTANCE PROGRAMS APPLICABLE TO THE U. S. PHOTOVOLTAIC INDUSTRY". THIS REPORT, UPON WHICH THE EXPORT COUNCIL FOR

RENEWABLE ENERGY IS PROUD TO HAVE COLLABORATED, OFFERS AN EXHAUSTIVE REVIEW OF FEDERAL EXPORT ASSISTANCE PROGRAMS, WITH PARTICULAR EMPHASIS ON THEIR EXPERIENCE WITH AND AVAILABILITY TO U. S. PHOTOVOLTAIC EXPORTERS. A MORE GENERAL BUT EQUALLY COMPREHENSIVE REVIEW OF FEDERAL EXPORT PROGRAMS IS CONTAINED IN A BOOK EDITED BY MR. WILLIAM A. DELPHOS, VICE PRESIDENT FOR OPERATIONS OF THE OVERSEAS PRIVATE INVESTMENT CORPORATION AND PUBLISHED BY JOHN WILEY & SONS, NEW YORK, ENTITLED WASHINGTON'S BEST KEPT SECRETS: A U. S. GOVERNMENT GUIDE TO INTERNATIONAL BUSINESS. I DO HAVE GENERAL OBSERVATIONS TO MAKE HERE TODAY ABOUT THE ADEQUACY OF THESE PROGRAMS TO THE NEEDS OF THE U. S. PHOTOVOLTAIC INDUSTRY. AND BEYOND THAT, I WILL BE HAPPY TO WORK WITH THE MEMBERS AND STAFF OF THE SUBCOMMITTEE ON DEVELOPING SPECIFIC PROGRAM RECOMMENDATIONS AS DESIRED OR AS APPROPRIATE.

IT HAS CONSISTENTLY BEEN INDUSTRY'S VIEW THAT A CRITICAL ROLE FOR THE FEDERAL GOVERNMENT TO PLAY IN SUPPORT OF RENEWABLE ENERGY INTERNATIONAL MARKET DEVELOPMENT IS IN ASSISTING INDUSTRY MEMBERS IN MAKING DIRECT CONTACT WITH POTENTIAL OVERSEAS CUSTOMERS AND PARTNERS. THE SUBCOMMITTEE HAS RESPONDED TO THIS BY SUPPORTING THE ESTABLISHMENT IN 1982 OF A PROGRAM UNDER WHICH THE DEPARTMENT OF ENERGY MAKES RESOURCES AVAILABLE TO ASSIST THE PARTICIPTION BY RENEWABLE ENERGY COMPANIES IN THE TRADE DEVELOPMENT PROGRAM OF THE INTERNATIONAL TRADE ADMINISTRATION OF THE DEPARTMENT OF

COMMERCE. THIS PROGRAM SPONSORS INDUSTRY MISSIONS OF EITHER COMMERCIAL OR TECHNICAL EMPHASIS TO SELECTED MARKET NATIONS, WHERE MEETINGS WITH KEY PUBLIC AND PRIVATE SECTOR INDIVIDUALS ARE CONDUCTED. IT ALSO ORGANIZES U. S. INDUSTRY PAVILIONS AT OVERSEAS TRADE FAIRS, PRODUCT CATALOG AND VIDEO CATALOG SHOWS OF U. S. PRODUCTS FOR DISPLAY IN INDIVIDUAL COUNTRIES OR SEQUENCES OF COUNTRIES. AND IT HAS RECRUITED FOR AND ASSISTED THE PARTICIPATION IN ANNUAL RENEWABLE ENERGY TRADE FAIRS IN THIS COUNTRY OF PUBLIC AND PRIVATE SECTOR INDIVIDUALS FROM SELECTED MARKET COUNTRIES. THIS PROGRAM IS CONDUCTED FOR ALL U. S. INDUSTRIES ON A STRICT FULL COST RECOVERY BASIS, THUS THE COST SHARING SUPPORT PROVIDED FOR RENEWABLE ENERGY COMPANIES (ON AVERAGE, 50% OF THE TOTAL COST OF THE TRIP, COVERING ADMINISTRATIVE EXPENSES IN THE CASE OF INDUSTRY MISSIONS AND COVERING BOOTH SPACE AND SUPPORT SERVICES IN THE CASE OF OVERSEAS TRADE FAIRS) IS OF SIGNIFICANT ASSISTANCE. IT IS MY UNDERSTANDING THAT THE OVERSEAS MISSIONS SUPPORT IS MOST SIGNIFICANT FOR COMPANIES WHICH ARE NEW TO THE PARTICULAR MARKETS. SINCE TRAVEL AND ACCOMMODATIONS ARE NOT COVERED BY THE COST SHARING ASSISTANCE, THE MISSIONS ARE OF SOMEWHAT LESS INCREMENTAL VALUE TO COMPANIES WITH ESTABLISHED TIES IN THE PARTICULAR MARKET.

WHILE THIS PROGRAM IS NOT AS FLEXIBLE NOR AS FINANCIALLY SUPPORTIVE AS SOME OTHER NATION'S PROGRAMS (E. G. AUSTRALIA, WHERE UP TO 70% OF A COMPANY'S EXPORT PROMOTION COSTS, INCLUDING

INDIVIDUAL COMPANY PROMOTION TRIPS, ARE REIMBURSED BY THE GOVERNMENT), IT PROBABLY OFFERS THAT MAXIMUM DEGREE OF ASSISTANCE AVAILABLE UNDER THE INTERNATIONAL TRADE ADMINISTRATION AUSPICES.

THE ONLY OTHER PROGRAM OF POTENTIALLY COMPARABLE VALUE TO THE INDUSTRY IS ONE CONDUCTED ON A VERY LIMITED BASIS BY THE AGENCY FOR INTERNATIONAL DEVELOPMENT (AID). THROUGH THIS ACTIVITY, GROUPS OF INDUSTRY REPRESENTATIVES WERE TAKEN TO SELECTED DEVELOPING COUNTRIES FOR MEETINGS WITH POTENTIAL PROJECT DEVELOPERS AND JOINT VENTURE PARTNERS. ALL COSTS WERE PAID BY AID. THERE WERE APPARENTLY SUCCESSFUL EVENTS FOR THE INDUSTRY PARTICIPANTS, AND I WOULD HOPE THAT THE PROGRAM MIGHT BE RESUSCITATED BY THE AGENCY.

IN GENERAL , AS I STATED, I BELIEVE THAT FEDERAL SUPPORT FOR RENEWABLE ENERGY INTERNATIONAL MARKET DEVELOPMENT MISSIONS ARE BOTH IMPORTANT FOR THE INDUSTRY, ASSISTING AS THEY DO IN OFFSETTING ACTIVITIES OF CONSIDERABLE EXPENSE, AND FOR THE NATION AS A WHOLE, IN THAT THEIR HIGH SUCCESS RATE JUSTIFIES THEIR VALUE IN OUR INTERNATIONAL TRADE BALANCE.

IN THE AREA OF FEASIBILITY ASSESSMENT, THERE ARE A NUMBER OF FEDERAL PROGRAMS THAT ASSIST IN THE FINANCING OF FEASIBILITY STUDIES OF EXPORT TRANSACTIONS , OVERSEAS PROJECTS OR OVERSEAS JOINT VENTURES. ALMOST ALL ARE CONDUCTED ON A COST SHARED BASIS THROUGH

REIMBURSABLE GRANTS, REPAYABLE ONLY IF THE VENTURE PROCEEDS. THESE WOULD APPEAR TO BE ATTRACTIVE PROGRAMS FOR ESTABLISHED INDUSTRIES. HOWEVER, EVEN 40 TO 60 PERCENT OF THE COST OF A FEASIBILITY STUDY COSTING BETWEEN 50 AND 100 THOUSAND DOLLARS, IS A SUBSTANTIAL EXPENSE FOR A SMALL COMPANY OR DIVISION IN AN EMERGING INDUSTRY. I WOULD RECOMMEND THAT THE SUBCOMMITTEE EXPLORE THE POSSIBILITY OF ASSISTING THE DEPARTMENT OF ENERGY IN PROVIDING THE COMPANY'S SHARE OF THE EXPENSE OF THE FEASIBILITY STUDY, PERHAPS ALSO TO BE REIMBURSED IF THE VENTURE PROCEEDS.

THE FEASIBILITY ASSESSMENT PHASE OF PROJECT DEVELOPMENT IS PARTICULARLY CRITICAL, IN THAT THE SPECIFICATIONS WRITTEN INTO THE PROJECT DESIGN OFTEN ARE TAILORED TO PRODUCTS FROM THE DESIGNER'S OWN COMPANY OR COUNTRY. THIS MAKES IT MUCH MORE DIFFICULT TO PARTICIPATE IN A PROJECT IF THE STUDY IS FUNDED AND PERFORMED BY A FOREIGN COMPANY.

ONE OTHER ISSUE LIMITS THE USEFULNESS OF THE TRADE AND DEVELOPMENT'S FEASIBILITY STUDY PROGRAM TO THE U. S. PHOTOVOLTAIC INDUSTRY. THE PROGRAM GUIDELINES SPECIFY THAT FUNDING FOR A FEASIBILITY STUDY IS AVAILABLE ONLY IF THE TOTAL VALUE OF U. S. EXPORTS LIKELY TO RESULT FROM IT ARE WORTH 75 TO 100 TIMES THE COST OF THE STUDY. THIS, PLUS THAT FACT THAT SEVERE STAFF CONSTRAINTS AT THE PROGRAM OFFICE CONSTRICT THE NUMBER OF APPLICATIONS

THAT CAN BE HANDLED (THUS ENCOURAGING THE STAFF TO CONCENTRATE ON FEWER NUMBERS OF LARGER PROJECTS), RESTRICTS ACCESS TO THE PROGRAM'S FUNDING SUPPORT FOR SMALL BUSINESSES PURSUING SMALLER OVERSEAS PROJECTS. I WOULD STRONGLY RECOMMEND THAT, TO THE EXTENT POSSIBLE, THE DEPARTMENT OF ENERGY BE ENCOURAGED TO FIND WAYS TO PROVIDE TECHNICAL SUPPORT TO THE TRADE AND DEVELOPMENT PROGRAM STAFF TO PERMIT IT TO PROCESS FEASIBILITY STUDY APPLICATIONS IN THE PHOTOVOLTAIC AND OTHER RENEWABLE ENERGY FIELDS.

THE COMMERCIAL EXPORT TRANSACTION FINANCING PROGRAM OF THE UNITED STATES, THE EXPORT IMPORT BANK, IS GOVERNED WITH RESPECT TO THE INTEREST RATES IT CAN OFFER TO U. S. EXPORTERS BY THE FORMAL ARRANGEMENT OF THE ORGANIZATION OF ECONOMIC COOPERATION AND DEVELOPMENT. U. S. COMMERCIAL EXPORT FINANCING RATES, LIKE THOSE OF ALL OF THE SIGNATORIES TO THE ARRANGEMENT, ARE TIED TO THE PREVAILING DOMESTIC COMMERCIAL INTEREST RATES. STRICT ADHERENCE TO THIS ARRANGEMENT IS THE POLICY OF THE FEDERAL GOVERNMENT. THE UNFORTUNATE RESULT OF THIS SITUATION IS THAT JAPANESE, WEST GERMAN AND DUTCH EXPORTERS, WHOSE COUNTRIES' COMMERCIAL INTEREST RATES ARE SIGNIFICANTLY LOWER THAN THOSE OF THE UNITED STATES AND THE OTHER OECD MEMBER NATIONS, ENJOY COMMERCIAL EXPORT FINANCING ADVANTAGES. EX IM IS WILLING TO DEPART FROM THIS STANDARD ONLY IN THE EVENT THAT A U. S. EXPORTER FACES MIXED CREDIT FINANCING MADE AVAILABLE TO A FOREIGN COMPETITOR BY ITS GOVERNMENT. MIXED CREDITS

OCCUR WHEN FOREIGN ASSISTANCE FUNDS ARE BLENDED WITH COMMERCIAL FINANCING TO BRING DOWN THE OVERALL INTEREST RATE OF THE FINANCIAL PACKAGE. ON 3 RECENT OCCASIONS, EX IM HAS OFFERED TO FINANCE TRANSACTIONS AT HIGHLY CONCESSIONAL RATES SET TO PRECISELY MEET THE CONDITIONS OFFERED THROUGH FOREIGN MIXED CREDIT PACKAGES. NONE OF THESE, HOWEVER, OCCURRED IN THE RENEWABLE ENERGY FIELD.

EX IM PROGRAMS FOR MEDIUM TERM FINANCING (6 MONTHS TO 5 YEARS) CONSIST OF GUARANTEES ON COMMERCIAL LOANS TO EXPORTERS. THESE GUARANTEES CAN HAVE THE EFFECT OF MAKING AVAILABLE COMMERCIAL FINANCING AT AS MUCH AS A FULL PERCENTAGE POINT BELOW WHAT WOULD BE OFFERED IN THEIR ABSENCE, A FACTOR OF SIGNIFICANCE TO ANY U. S. EXPORTER. IT IS INTERESTING TO NOTE, HOWEVER, THAT THE USE OF EX IM PROGRAMS BY THE PHOTOVOLTAICS INDUSTRY HAS BEEN EXTREMELY LIMITED, CONSISTING OF A SINGLE TRANSACTION, A SALE OF PHOTOVOLTAIC POWER SYSTEMS FOR A TELECOMMUNICATIONS PROJECT IN COLOMBIA IN 1982. HOPEFULLY, AS A RESULT OF EFFORTS SUCH AS THE VERY PRODUCTIVE PHOTOVOLTAIC EXPORT ASSISTANCE SEMINAR CONDUCTED LAST WEEK BY THE DEPARTMENT OF ENERGY, THE INDUSTRY WILL MAKE FULLER USE OF EX IM RESOURCES.

THE FINAL ASPECT OF THE FINANCING ISSUE THAT I WANT TO ADDRESS TODAY IS THE AREA OF DEVELOPMENT ASSISTANCE. IT IS IN THIS AREA THAT THE PHOTOVOLTAIC INDUSTRY'S GREATEST INVOLVEMENT WITH

OVERSEAS GOVERNMENT FINANCING HAS OCCURRED AND IN WHICH I BELIEVE THE GREATEST NEAR TERM POTENTIAL STILL EXISTS. I USE THE TERM FINANCING SOMEWHAT LOOSELY HERE, FOR EXPORT FINANCING IS NOT THE STATED PURPOSE OF THE U. S. GOVERNMENT'S FOREIGN ASSISTANCE AGENCY, THE AGENCY FOR INTERNATIONAL DEVELOPMENT (AID). AID'S MANDATE IS TO STIMULATE ECONOMIC DEVELOPMENT IN THE LESS DEVELOPED WORLD. EXPORTS OF U. S. PRODUCTS OR TECHNOLOGY IS, AND IN ALL LIKELIHOOD WILL ALWAYS BE, SECONDARY TO THAT MISSION. HELPING ITS CLIENTS TO DEVELOP ALTERNATIVES TO IMPORTED OIL AS AN ENERGY SOURCE IS CENTRAL TO AID'S MISSION, AND THIS HAS BROUGHT ITS ATTENTION TO PHOTOVOLTAICS AND OTHER RENEWABLE ENERGY TECHNOLOGIES. THE AID OFFICE OF ENERGY HAS SUPPORTED A NUMBER OF DEMONSTRATIONS OF PHOTOVOLTAIC SYSTEMS, BUT WITH VERY MIXED SUCCESS. MY IMPRESSION IS THAT THIS DEMONSTRATION PROGRAM SUFFERED FROM SIMILAR PROBLEMS EXPERIENCED IN DOMESTIC DEMONSTRATION PROGRAMS, IN THAT TECHNOLOGIES WHICH WERE NOT COMMERCIALY READY, BUT UPON WHICH HIGH EXPECTATIONS WERE PLACED, EXPERIENCED OPERATIONAL PROBLEMS WHILE EXHIBITING HIGH SYSTEM COSTS. THE RESULT HAS BEEN A WIDESPREAD DISENCHANTMENT WITH PHOTOVOLTAICS WITHIN AID WHICH WILL BE DIFFICULT TO OVERCOME.

SOME AID COUNTRY MISSIONS, AND IT IS THE COUNTRY MISSIONS WHICH ACTUALLY CONTROL THE BULK OF THE AGENCY'S FUNDING RESOURCES, HAVE SUPPORTED PHOTOVOLTAIC PURCHASES BY THEIR CLIENTS. THE MORE RECENT OF THESE ARE OPERATING SUCCESSFULLY. BROADER SUPPORT FOR

PHOTOVOLTAIC USE BY THE AGENCY WILL, IN ALL LIKELIHOOD, HAVE TO AWAIT THE REEDUCATION OF AID'S COUNTRY OFFICERS AS TO THE TRUE COST AND OPERATIONAL CAPABILITIES OF PHOTOVOLTAICS AND PHOTOVOLTAIC POWERED SYSTEMS. THIS SITUATION IS AN APPROPRIATE ONE FOR THE ATTENTION OF THE SUBCOMMITTEE, EXPERIENCED AS IT IS IN THE DEVELOPMENT OF TECHNOLOGIES AND IN THE DISSEMINATION OF INFORMATION ABOUT THEM TO POTENTIAL USER GROUPS. IT IS ALSO AN APPROPRIATE SITUATION TO BE ADDRESSED BY THE DEPARTMENT OF ENERGY, WITH THE IDENTICAL PERSPECTIVE BUT WITH THE ADDITIONAL FINANCIAL AND ADMINISTRATIVE RESOURCES TO DEAL DIRECTLY WITH THE PROBLEM. THE DEPARTMENT DOES APPEAR TO BE COMMITTED TO HELPING AID UPDATE ITS INFORMATION ON PHOTOVOLTAICS AND OTHER RENEWABLE ENERGY TECHNOLOGIES, PRINCIPALLY THROUGH A GREATLY EXPANDED TECHNOLOGY TRANSFER PROGRAM. I MIGHT ADD HERE THAT THIS EDUCATION PROCESS WILL BE EXTREMELY USEFUL TO THE INDUSTRY IN ESTABLISHING TECHNICAL AND COMMERCIAL CREDIBILITY WITH THE REST OF THE GOVERNMENT'S EXPORT RELATED PROGRAMS. I URGE THE SUBCOMMITTEE TO STRONGLY SUPPORT THE DEPARTMENT IN THE EXPANSION OF ITS TECHNOLOGY TRANSFER PROGRAM.

THERE IS AN ADDITIONAL REASON, OTHER THAN STIMULATING DIRECT PROCUREMENTS FROM AID CLIENT NATIONS, TO HELP AID REALIZE THE COMMERCIAL VIABILITY OF PHOTOVOLTAICS. A GROWING FOCUS OF AID'S ECONOMIC DEVELOPMENT MISSION IS THE FACILITATION OF JOINT VENTURE AGREEMENTS BETWEEN U. S. AND CLIENT NATION BUSINESSES.

THERE IS GROWING INTEREST AMONG DEVELOPING NATIONS IN PARTICIPATING IN THE ECONOMIC BENEFITS OF PRODUCT MANUFACTURE. "LOCAL CONTENT" IS THE TERM OF ART MOST OFTEN USED TO DESCRIBE THIS OBJECTIVE. A NUMBER OF U. S. PHOTOVOLTAIC MANUFACTURERS ARE, IN PART AT LEAST, BASING THEIR MARKETING STRATEGIES ON MEETING THIS INTEREST. AND WE HAVE FOUND IN OUR STUDY OF THE RENEWABLE ENERGY PROGRAMS OF OUR FOREIGN COMPETITORS THAT THIS TYPE OF JOINT VENTURE MARKETING STRATEGY IS WIDELY PERCEIVED BY FOREIGN COMPANIES TO BE THE MOST EFFECTIVE WAY TO ESTABLISH SUSTAINABLE, COMPETITIVE POSITIONS IN INTERNATIONAL MARKETS. IT REMAINS TO BE SEEN HOW MUCH OF THE PRODUCTION OR ASSEMBLY PROCESS CAN OR SHOULD BE TRANSFERRED TO MARKET NATIONS, BUT IF IN FACT THIS TREND IS SIGNIFICANT, THEN DIRECTING THE INTEREST OF AID TOWARD ASSISTING THE FORMATION OF OVERSEAS JOINT VENTURES AROUND PHOTOVOLTAIC AND OTHER RENEWABLE ENERGY TECHNOLOGIES WILL BE EXTREMELY VALUABLE.

THE INTERAGENCY WORKING GROUP ON INTERNATIONAL RENEWABLE ENERGY DEVELOPMENT OFFERS THE IDEAL FORUM FOR THE EDUCATION PROCESS I HAVE JUST DISCUSSED. BUT IT ALSO OFFERS POSSIBILITIES FOR INNOVATIVE APPROACHES TO POLICY ANALYSIS AND PROGRAM MANAGEMENT. IT PRESENTS AN OPPORTUNITY TO VIEW THE CONTINUUM OF INTERNATIONALLY ORIENTED FEDERAL PROGRAMS AS THEY RELATE TO A GROUP OF YOUNG, FAST GROWING, INTERNATIONALLY DIRECTED INDUSTRIES. IN THIS WAY I HOPE THAT THE GROUP IS USEFUL TO THE TRADE POLICY SECTOR FOR ITS

INTERESTS. THUS IT OFFERS THE OPPORTUNITY TO IMPROVE THE INTEGRATION OF THE VARIOUS INTERNATIONAL PROGRAMS, MUCH AS OUR COMPETITOR NATIONS DO SO SUCCESSFULLY. ORCHESTRATING THE RESOURCES OF OUR VARIOUS TRADE RELATED PROGRAMS, ON BEHALF EVEN OF INDIVIDUAL PROJECTS AND TRANSACTIONS, WILL ALLOW US TO MAXIMIZE THE LEVERAGE OF FEDERAL ASSISTANCE TO THE DIRECT BENEFIT OF THE PHOTOVOLTAIC INDUSTRY AND THE OTHER RENEWABLE ENERGY INDUSTRIES. THIS PERSPECTIVE IS ONE WHICH THE EXPORT COUNCIL FOR RENEWABLE ENERGY HAS CONSISTENTLY TAKEN IN OUR SUPPORT FOR THE IDEA OF THE INTERAGENCY WORKING GROUP. AND I HAVE STRONGLY RECOMMENDED TO THE DEPARTMENT OF ENERGY THAT IT INCLUDE THIS APPROACH IN THE AGENDA IT SETS BEFORE THE GROUP. I AM CONVINCED THAT IT CAN BRING TANGIBLE RESULTS TO THE INDUSTRY AND THE NATION AS A WHOLE. I AM ENCOURAGED THAT THE DEPARTMENT HAS ENTHUSIASM FOR THIS TYPE OF UNDERTAKING AS WELL. I WOULD CLOSE BY URGING THE SUBCOMMITTEE TO PROVIDE THE DEPARTMENT THE SUPPORT IT WILL NEED IN THIS AREA.

AGAIN, THANK YOU FOR OFFERING ME THE OPPORTUNITY TO DISCUSS THESE ISSUES WITH YOU TODAY.

Mr. OTTINGER [acting chairman]. Thank you very much, Mr. Enfield.

Without objection, we will put everybody's full statement in the record. Since we have a good number of witnesses and a good number of questions, if you can summarize your statements, it would be appreciated. We would probably get more, since we have read the testimony, from having you answer some questions rather than to read the full statements.

Mr. Ragsdale, we are pleased to have you here and to receive your testimony.

**STATEMENT OF CLYDE RAGSDALE, SOLAVOLT INTERNATIONAL,
PHOENIX, AZ**

Mr. RAGSDALE. Thank you, Mr. Chairman.

I am happy to be here. I would like to bring you up to date since the last time you visited us, we were Motorola in Phoenix when we were starting our work in ribbon. We have advanced further on that. I would like to give you just a brief synopsis or background of who Solavolt is, since we are not your everyday household word today.

We are a partnership of Motorola Solar Energy, Inc., which is a subsidiary of Motorola, and SES, Inc., a subsidiary of Shell Oil. Both companies have been involved in photovoltaics for a significant number of years. We both started our own individual efforts in about 1974. SES, the Shell part of the organization, started their work in thin film technologies, R&D work primarily, specifically cadmium sulfide. Through the early 1981 period, that technology had not been successfully commercialized at that point.

Motorola started at about the same time with its silicon ribbon process, first funded solely by Motorola and then later assisted by some U.S. Government funds but really needed more funding or larger funding to advance the technology development.

These two circumstances, with one company needing more funding and the other needing a more commercially viable technology, led to the formation of Solavolt International just about 3 years ago. We have pursued both the thin film and ribbon technologies, in fact, developed the cadmium sulfide technology to the point of being able to consistently produce stable, 8 percent, large area efficient cells. However, when viewed in comparison with the nearer term commercial opportunities promised by the ribbon process, ribbon was the better investment choice for the limited funds available.

For that reason, the thin film division of Solavolt was dissolved in 1983. SES later transferred this cadmium sulfide technology to the University of Delaware who are planning further R&D efforts in that area.

By the time this process is commercialized next year, the total investment by Solavolt and its predecessor organizations will be in the neighborhood of \$100 million and will represent many hundreds of man-years of effort. This investment, however, should result in a manufacturing process which will be capable of reducing our manufacturing costs to less than half its cost today. That is

opening up enormous markets in the future, because it is a very price elastic market.

Mr. OTTINGER. What figure cost per peak watt do you—

Mr. RAGSDALE. We think, with sufficient volume, moving down the experience curve, that technology will get us on the start of the experience curve and volume then will move us down it, we believe that we can successfully sell, on a profitable basis, at the \$2 to \$3 per watt range when we get far enough down the line. Some of our technical people feel they can get us below that. As a marketing man, I tell them to get me to \$2 or \$3 and that is a huge market for me to work with.

Mr. OTTINGER. Thank you.

Mr. RAGSDALE. As you can see, these PV technologies don't come cheaply and have no guarantee of desired results. On the other hand, without a next generation low cost process with some likelihood of success, the probability of long-term survival of a PV company is slim. I believe this is the reason for the departure of some of the previous participants in the PV industry which your information had previously described.

On our side, we decided early on to concentrate marketing efforts in the international markets, particularly developing countries, primarily because we felt this is where the greatest market potential was, particularly in the near-term, and this was mainly due to their limited electrification and significant need for energy to carry on their development programs.

It was a little easier for us to concentrate on developing countries than it might be for other companies due to Motorola's experience. We have had experience in Motorola selling communications equipment in these countries for many years, and there are very few countries in the free world where Motorola has not had a distributor or other entity representing the company for many years. It is therefore relatively simple and less painful for Solavolt salespersons to visit these countries and take advantage of the Motorola presence and knowledge there.

The primary market in PV in the developing countries for the next several years will be in remote, stand-alone applications. The grid in these countries is just not well developed. Typically only the major towns and cities are electrified. This leaves many villages and rural areas with no electricity other than an occasional diesel electric generator. These generators, in addition to suffering from inadequate and expensive fuel supplies, often break down. Maintenance and repair capability is not usually locally available, so they will sit there for long periods of time rusting and wearing out.

The early uses of PV in these areas are mostly satisfying basic human needs. In addition to emergency communications, PV systems, as you well know, are used for providing power for water pumps, to provide sanitary water supplies, for stock watering and possibly for irrigation where they may increase the crops from one to two crops per year or maybe one rather than none. It can also be used for lighting, safety and security, or for education, for power radios or TV's in educational programs, and remote medical dispensaries can now store vaccines for immunization and inoculation programs which otherwise would not be possible. We have in-

stalled about 50 of these medical refrigeration systems scattered around the world.

These small systems can be enlarged in the future to provide combinations of these various applications and can grow into what we call a village power system. Longer term, they can use PV to supplement the inadequate, often unreliable power for the towns and the cities.

It is therefore quite obvious that PV can improve the quality of life and also possibly save lives of people in the developing countries.

If all this is true, why aren't PV systems being installed as rapidly as we can make them? The usual answer is cost, and that is indeed a significant part of it for widespread application. However, there are quite a few applications that are cost effective today.

The problems that we have are primarily that the people who could take the most advantage of them don't even know of their existence or, if they do, don't know of its economic viability, reliability, and other advantages inherent to it. The other major problem is that the high initial investment makes it difficult to finance PV projects. You put all your money up front, and it is very difficult for developing countries, whose economies are already strained and short of foreign exchange.

These are two areas that are obvious candidates for the U.S. Government to play a role in assisting the development of the PV market and aiding the U.S. PV industry to maintain its leadership position in this potentially huge market. This first obstacle is being addressed. The Department of Energy has sponsored several overseas demonstration projects with varying degrees of success but which have served to prove the mechanical feasibility of PV in numerous applications. They recently published, with industry assistance, an educational brochure on PV which will be given broad distribution through the U.S. overseas agencies and departments. This was first distributed last week at the Export Council meeting. We were talking about it, and it is a very well done brochure, and I think it will educate many of the people in the developing countries as to what photovoltaics is and how it can be used.

They also sponsored, just last week, as previously mentioned, an export workshop attended by many top level industry and Government leaders. The main thrust of this was for industry to inform the Government of industry's problems and needs in the export market and for the Government to tell us what services they have available to assist us. Hopefully, one end result of this workshop will be an increased awareness simply because of the workshop, an awareness of PV trickling down through the Government agencies, particularly those with overseas activities. They must be better informed about PV if they are to assist overseas customers in selecting U.S. products and systems.

A copy of the summary remarks by the PV industry is attached to my testimony.

The second obstacle, financing PV purchases, is an even more challenging problem, again, this problem being that you have your initial investment all up front, no continuing costs. It is not like buying a diesel generator where you can pay \$5,000 this year for

the generator and \$5,000 per year fuel costs. It all has to be invested up front.

This is a very formidable problem, especially when you consider times like the present when the dollar is so strong and the interest rates are so high. Not some, but most of our foreign competitors are being assisted in this area by their governments, either with no or low interest loans, cost sharing, or outright grants. The United States is occasionally doing this indirectly through U.S. AID projects which usually require purchase of U.S. manufactured products as a condition of the contract.

However, at this workshop, it became even more obvious that we had a gap in the U.S. Government export support. Programs to support and facilitate investment of capital in developing countries through Exim, OPIC, SBA, TDP, et cetera, are in place and appear to be a good start in that direction. Also, programs to support large dollar, \$1 million and up, export sales also appear to be adequate.

The problem is, as described earlier, the present and near future potential market for PV is going to be in a large number of small, \$100,000 to \$1 million systems, or possibly even smaller than the \$100,000 in a large number of developing countries. This is sort of like planting seeds to grow into a larger harvest later.

AID has sponsored a few programs which could fill this gap. They have sponsored water pumping projects, remote medical centers, and village power systems. However, in terms of an overall solution to the small system market support, two problems exist.

AID is either not convinced of the viability for PV for these types of systems, or, if they are, they have not communicated it with conviction down through their regional and field offices. Most of the small projects have been initiated by only a few field offices, which is fine, but if PV works for them, why not for the others.

AID's main mission is to conduct assistance programs directed toward satisfying basic human needs and improving economic growth in developing countries. So far, it sounds like a natural activity to support small PV system export efforts, right? Wrong. The problem is they do not believe that they should, or have the charter, to support the development of markets for U.S. products.

Unfortunately, our foreign competitors' governments do believe that a role of their development assistance programs is to develop export market for their products. The French, Germans, and Japanese do an excellent job in this regard.

To be fair, some of the AID field offices are supportive of PV and supportive of U.S. suppliers. In my travels through the developing countries, I will often stop by the U.S. AID mission to bring them up to date on PV and search for appropriate programs. Most of the mission officers are quite supportive and some of them, once acquainted with PV, are quite enthusiastic. This is quite important, because in many of these countries, the AID technical people are considered to be the experts on U.S. technology. If they are not supportive of PV, the locals are less likely to believe in it.

As recommendations to overcome these obstacles to small system PV market development in developing countries, I would like to offer the following for your consideration:

As a minimum, if convinced that PV is a viable energy source for these small systems, AID must communicate this down through

their field offices and train their people in its benefits. If they are not convinced of PV's viability, we in industry will convince them, because we are convinced that it is viable in these applications.

A second thought for your consideration would be the establishment of a pool of money to be used in a similar manner to the domestic FPUP, Federal Photovoltaic Utilization Program. As you may recall, in this program, DOE established a fund which other agencies, such as the National Park Service, the Forest Service, et cetera, could draw on to help finance the PV portion of a project that might otherwise have been powered by a diesel generator. Use of these funds encouraged the agencies to at least give consideration to PV as a power source. As a result of the familiarity with the effectiveness of PV, some of these agencies are now routinely using PV where it is cost effective. The FPUP program therefore performed the role of information and education as well as providing some funding.

A similar pool of money could be identified and earmarked for PV, for export assistance with PV, possibly within the DOE budget. These funds would then be available to be used as soft loans, cost share programs, and occasionally as direct grants. The flow of these funds could be administered through U.S. AID or Eximbank.

When a U.S. PV company developed a program or project with a customer, and the up-front cost proved to be a barrier, the PV company and/or the customer would approach the overseas local AID mission for consideration of providing some portion of the funds or possibly providing discretionary loans. The larger projects could possibly be funded through Eximbank.

These funds should not be applied to unrealistic demonstrations but to programs or projects that are truly cost effective, suffering only from either the large initial capital outlay problem or to share the risk where the purchaser may be uncertain about PV. These projects, where initiated by a U.S. PV supplier, or his representative, would not have to be competitively tendered, thus insuring that the U.S. PV suppliers market development efforts and expense were not invested for someone else's benefit.

The benefits from such a program would flow not only from the individual project undertaken, but also from the resulting familiarity and comfort level of working with PV. Then, with time, and the continuing decreasing initial cost of PV systems due to PV cost reduction programs, this program could be gradually phased out over a 4- to 5-year period.

No doubt there may be other solutions to the problem of stimulating widespread use of PV in small system applications, but the use of a small pool of funds, administered through U.S. AID, seems to be a natural, low-cost solution. The infrastructure is there, via the U.S. AID field offices, the need is there, and in the long term the donor funds will be there. All that is needed at the beginning is a little pump priming. Once that is done, rest assured that the dynamic U.S. PV industry will expand and commercialize those opportunities in such a way as to improve our balance of trade, maintain our leadership in the PV industry, and improve the well being of those our systems serve.

Thank you.

[The prepared statement of Mr. Ragsdale follows:]

TESTIMONY
BEFORE
SUBCOMMITTEE ON ENERGY DEVELOPMENT & APPLICATION
OF
THE COMMITTEE ON SCIENCE AND TECHNOLOGY
OF
THE U.S. HOUSE OF REPRESENTATIVES
SEPTEMBER 19, 1984

I am Clyde Ragsdale, Manager of Marketing for Solavolt International which is a partnership of Motorola Solar Energy, Inc. (a subsidiary of Motorola Inc.) and SES, Incorporated (a subsidiary of Shell Oil Company). I have been involved in International Marketing for the past 17 years, and have spent the last 7 years in Marketing and Market Development of photovoltaics, resulting in extensive travel in developing countries.

I have been asked to testify on the issue of export sales of renewable energy equipment and the adequacy of government incentives for such sales.

To put my later comments into perspective, it might be useful to understand the background of Solavolt. These comments will also speak to your concerns about the near-term viability of the photovoltaic industry.

BACKGROUND

Both parent companies, SES, Incorporated, and Motorola Solar Energy, Inc. began their individual efforts in photovoltaics (PV) in 1974. Shell Oil Company bought a 20% share in SES in that year, subsequently increasing their ownership to 80%, then later, in 1979, to 100%. SES's efforts were in thin film, R&D, specifically cadmium-sulfide, and thru 1981, the technology had not been commercially successful.

Motorola started its activity on its silicon ribbon process in 1974, at first funded solely by Motorola, later assisted by some U.S. Government funds, but needed larger funding to really advance the technology development.

These two circumstances, one company needing more funding, the other one needing a more commercially technology, led to the formation of Solavolt International on September 30, 1981. Solavolt has pursued both the thin film and ribbon technologies, and in fact developed the cad-sulfide technology to the point of being able to consistently produce stable large-area 8% efficient cells. However, when viewed in comparison with the nearer term commercial opportunity promised by the ribbon process, ribbon was a better investment

choice for the limited funds available. For that reason, the Thin-Film Division of Solavolt International was dissolved in mid-1983. SES later transferred the cadmium-sulfide technology to the University of Delaware, who are planning further R&D in that area.

By the time the ribbon process is commercialized next year, the total investment by Solavolt and its predecessor organizations in the thin-film and ribbon development programs will be on the order of \$100 million and will represent many hundreds of man-years of effort. This investment should result in a manufacturing process capable of reducing PV manufacturing costs less than half of its cost today, thus opening up enormous markets in the future.

As you can see, the PV technologies don't come cheaply and have no guarantee of the desired results. On the other hand, without a next-generation, low-cost process with some likelihood of success, the probability of long term survival of a PV company is slim. I believe that this is the reason for the departure of some of the previous participants in the PV industry.

From the marketing side, Solavolt early-on decided to concentrate its marketing efforts on the international markets, particularly the developing countries. This stems from the belief that the greatest market potential, particularly in the near term, was in those areas. This is mostly due to their limited electrification and their significant need for energy to carry on their development programs.

For Solavolt, the decision to concentrate on developing country markets was easier than it might be for other companies, due to Motorola's experience. Motorola has been selling communication equipment in these countries for years, and there are very few countries in the free world where Motorola hasn't had a distributor or other entity representing the company for many years.

It is therefore relatively simple and less painful for a Solavolt sales person to visit these countries and take advantage of the Motorola presence and knowledge there. This background must also be borne in mind when considering our later comments about the problems and needs of U.S. industry to sell PV in the international markets.

APPLICATIONS

The primary market for PV in developing countries for the next several years will be in remote, stand-alone applications. The electricity grid in these countries is not well-developed. Typically only the major towns and cities are electrified. This leaves many villages and rural areas with no electricity other than an occasional diesel electric generator (DEG). These DEG's, in addition to suffering from inadequate and expensive fuel supplies, often break down. Since maintenance and repair capability is usually not locally available, these DEG's will sit unused for long periods often succumbing to terminal rust and/or fungus.

The early uses of PV in these areas are mostly satisfying basic human needs. In addition to emergency communications, PV systems provide power for water pumps, enabling people to have a sanitary water supply from a well, rather than drinking disease producing surface water. They can also have a source of water in drier areas for their livestock, and can increase their crop potential by irrigation, often resulting in two crops a year rather than one - or maybe none!

PV can be used to provide lighting, for safety and security or for education. It can power radios or TV's used for educational programs. Remote medical dispensaries can now store vaccines and other medicines in PV powered refrigerators, allowing immunization and inoculation programs which would otherwise not be possible. Solavolt has installed about 50 such systems.

Small PV systems can be enlarged in the future to provide combinations of these various applications and can grow into village power systems. Longer term they can use PV to supplement the inadequate, often unreliable power for the towns and cities.

It is therefore quite obvious that PV can improve the quality of life, and also possibly save lives of people in the developing countries.

If all this is true, why then aren't PV systems being installed as rapidly as they can be manufactured? The usual answer is cost. While it is true that large PV system may have a difficult time competing with a large DEG, many of the small systems mentioned before are cost-effective today and more applications are becoming cost-effective every day.

OBSTACLES

The two major obstacles to the development of the photovoltaic market in developing countries are:

1. Many of the people who could benefit from it the most are not aware of its existence or its reliability and economic viability today.
2. The high initial investment makes it difficult to finance PV projects, especially in developing countries whose economies are already strained and short of foreign exchange.

These two areas are obvious candidates for the U.S. government to play a role in assisting the development of the PV market and aiding the U.S. PV industry in maintaining a leadership position in this potentially huge market.

HOW ADEQUATE IS THE U.S. GOVERNMENT EFFORT TO HELP OVERCOME THESE OBSTACLES?

The first obstacle, lack of information and education on the practicality and economic viability of PV is already being addressed. The Department of Energy has sponsored several overseas demonstration projects which have served to prove the technical feasibility of PV in numerous applications. They have recently published, with industry assistance, an educational brochure on PV which will be given broad distribution thru U.S. overseas agencies and departments.

They also sponsored, just last week, an export workshop attended by many top level industry and government leaders. The main thrust of this workshop was for industry to inform the government of industry's problems and needs in the export market, and for the agencies to inform industry of the U.S. Government services available to assist exporters. Hopefully one end result of this workshop will be an increased awareness of PV trickling down thru the government agencies, particularly those with overseas activities. They must be better informed about PV if they are to assist overseas customers in selecting U.S. PV products and systems. (A copy of the summary remarks by the PV industry is attached.)

The second obstacle, financing PV purchases, is an even more challenging problem. Even though a PV system may be the most cost-effective solution to a given problem on a life-cycle basis, the fact that the total lifetime cost of the system is invested up-front represents a major problem to many of the less well-to-do customers. This is an even more formidable problem during times like the present, when the dollar is so strong and interest rates are so high.

Some of our foreign competitors are being assisted in this area by their governments, with either low or no-interest loans, cost sharing, or outright grants. The U.S. is doing this indirectly thru USAID projects, which usually require purchase of U.S. manufactured products as a condition of the contract.

However, it became even more clear at the export workshop that we have a gap in the U.S. Government export support effort.

The programs to support and facilitate investment of capital in developing countries thru EXIM, OPIC, SBA, TDP, etc. are in place and appear to be a good start in that direction. Programs to support large dollar (\$1million up) export sales also appear to be adequate.

The problem is, as described earlier, the present and near future potential market for PV is going to be in a large number of small (\$100,000 - \$1,000,000) systems in a large number of developing countries.

AID has sponsored a few programs which could fill this gap. They have sponsored water pumping projects, remote medical centers, and a village power system. However, in terms of an overall solution to the small system market support, two problems exist:

1. AID is either not convinced of the viability of PV for these types of systems, or, if they are, they have not communicated this conviction down thru their regional and field offices. Most of the small projects have been initiated by only a few field offices, which is fine, but if PV works for them why not the others?
2. AID's mission is to conduct assistance programs directed toward satisfying basic human needs and improving economic growth in developing countries. So far it sounds like a natural activity to support small PV system export efforts - right? Wrong! The problem is that they do not believe that they should, or have the charter to support the development of markets for U.S. products.

Unfortunately, our foreign competitor's governments believe that a role of their development assistance programs is to develop export markets for their products. The French, Germans, and Japanese do an excellent job in this regard.

To be fair, some of the AID field offices are supportive of PV, and supportive of U.S. suppliers. In my travels thru the developing countries, I will often stop by the U.S. AID mission to bring them up-to-date on PV and to search for appropriate programs to use PV. Most of the mission officers are quite supportive and some of them, once acquainted with PV are quite enthusiastic. This is quite important, because in many of these countries the AID technical people are considered to be the experts on U.S. technology. If they are not supportive of PV, the locals are less likely to believe in it.

RECOMMENDATIONS

To overcome these obstacles to small system PV market development in developing countries, I would like to offer the following for your consideration:

1. Communications

As a minimum, if convinced that PV is a viable energy source for these small systems, AID must communicate this down thru their field offices and train their people in its benefits. If not convinced of PV's viability, we in industry will convince them.

2. Funding

A second thought for your consideration would be the establishment of a pool of money to be used in a similar manner to the domestic FPUP (Federal Photovoltaic Utilization Program). As you may recall, in this program D.O.E. established a fund which other agencies, such as the National Park Service, the Forest Service, etc., could draw on to help finance the PV portion of a project that might otherwise have been powered by a diesel generator. Use of these funds encouraged the agencies to at least give consideration to PV as a power source, and as a result of the

familiarity with the effectiveness of PV, some of these agencies are now routinely using PV, where cost-effective. The FPUP therefore performed the role of information and education as well as providing some funding.

A similar pool of money could be identified and earmarked for PV, possibly within a DOE budget. These funds would then be available to be used as soft loans, cost-share programs, and occasionally as direct grants. The flow of these funds could be administered thru USAID or Eximbank. When a U.S. PV company developed a program or project with a customer, and the up-front cost proved to be a barrier, the PV company and/or the customer would approach the overseas local USAID mission for consideration of providing some portion of the funds or providing discretionary loans. The larger projects could possibly be funded thru Eximbank. The funds would not be applied to unrealistic demonstrations, but to programs or projects that were truly cost-effective, suffering only from either the large initial capital outlay problem, or to share the Risk where the purchaser may yet be uncertain about PV. These projects, where initiated by a U.S. PV supplier, or his representative, would not have to be competitively tendered, thus insuring that the U.S. PV suppliers market development efforts and expense were not invested for someone else's benefit.

The benefits from such a program would flow not only from the individual project undertaken, but also from the resulting familiarity and comfort level of working with PV. Then, with time, and the continuing decreasing initial cost of PV systems due to PV cost reduction, the program could be gradually phased out over a 4 to 5 year period.

CONCLUSION

No doubt there may be other solutions to the problem of stimulating the widespread use of PV in small system applications, but the use of a small pool of funds, administered thru US AID seems to be a natural, low-cost solution. The infrastructure is there, via the US AID field offices, the need is there, and in the long term the donor funds will be there. All that is needed at the beginning is a little pump-priming. Once that is done, rest assured that the dynamic U.S. PV industry will expand and commercialize those opportunities in such a way as to improve our balance of trade, maintain our leadership in the PV industry, and improve the well being of those our systems serve.

PHOTOVOLTAIC EXPORT ASSISTANCE SEMINAR

SEPTEMBER 18, 1984

SUMMARY REMARKS

by

Wm. H. O'Connor
Solavolt International
Moderator, Industry Panel

This completes our panels' presentation on the international marketing of PV. I trust that some points came through clearly. However it has been a long session, so I will try to summarize our thoughts on the governments programs for export assistance. In doing this I must again note that the number and variety of companies in the industry naturally leads to a wide variety of opinions, some possibly in conflict. However I think we do have reasonable consensus on the following.

First, we do not seek additional funding or new programs. We believe that what is available today may be adequate if PV is properly recognized and attracts its appropriate share of those resources. Considering the national deficit situation, I would not expect much disagreement here.

In a more positive and specific sense, we would like to see following:

- . Most importantly, broader education of U.S. government people here and abroad on PV and on the role it is capable of playing. (We must emphasize our many successes, not the few problems that have occurred).
- . Mandated consideration of PV on all government-supported programs where it might be economically or politically justified.

- . Expanded efforts to help educate offshore customers and users, with the associated government endorsement of US technology and industry. Bud Annan's new brochure is an excellent example of such an activity.
- . Continuation of existing market development and support programs, such as the Department of Commerce trade shows, exhibits, Agent/Distributor Service, Overseas Business Reports, WTDR's, etc.

We would like to see greater recognition of the need for supporting programs that are not in the million-dollar range, as a necessity for market development and subsequent growth to larger programs.

We believe that grants, loans, credits, and other funding support should go directly to offshore customers/users/and governments, with full Buy America provisions strictly enforced, to provide competitive opportunities for U.S. companies.

We recommend that any demonstration projects -- and we do think them important -- should be carried out at the commercial level, rather than through government agencies and laboratories with their associated overhead, and heavy demands for documentation and other non-hardware line items.

Finally, as a specific counter to foreign government-industry programs, we need incentives and better mechanisms to develop more aggressive and comprehensive financing and support packages. We particularly look forward to the discussions on that subject in this afternoons session.

With that summary, we close the industry panels presentation. We extend our deep appreciation to Secretary Hodel, Undersecretary Collins, Assistant Secretary for Renewables San Martin, Photovoltaic Division Director Annan, and all the others in DOE who conceived and supported this seminar, as well as to those from other governmental agencies who are participating here today. I trust that the industry attendance and enthusiasm tells you how much we appreciate this unique opportunity. Thank you all.

Mr. OTTINGER. Thank you, Mr. Ragsdale.

We will proceed for another 5 minutes or so, and then we will have to break for the vote.

Mr. Sklar, it is a pleasure to have you back before the subcommittee. We welcome your testimony.

STATEMENT OF SCOTT SKLAR, DIRECTOR OF PROGRAMS, SOLAR ENERGY INDUSTRIES ASSOCIATION, WASHINGTON, DC

Mr. SKLAR. Thank you, Mr. Chairman.

I will keep my remarks brief.

We were asked to testify on the Defense procurement practices, mostly for photovoltaics.

You should know that, as a result, that our association strongly supported Congressman Mavroules' amendment to the Defense Authorization Act directing the Department of Defense to procure solar devices as cost effective. As a result of the passage of that amendment, SEIA arranged a briefing this summer for the U.S. Department of Defense procurement officials at the Pentagon. We had representatives from our technical divisions to brief these individuals who were procurement officials from all the branches of DOD's services.

The bottom line on it was to see what technical objections they had, if any, to our broad range of technologies. We briefed them on active solar heating and cooling, thermosyphon, high temperature solar thermal, photovoltaics, and utilities' use of solar.

What we got out of the interchange after our briefing was that the Federal procurement people in Defense had no problems technically with any of these solar technologies. They told us, "there is no discouragement for the procurement of these solar technologies on a case-by-case basis." However, there is a big "but." What we found out was that most of the procurement, the actual writing for proposals and the technical descriptions for procuring solar, were done at the local level by the local procurement people, not by the people in the Pentagon.

So, we asked what do we do now, since you are on our side? Their response was that we ought to meet with the local procurement people to get them on our side.

So, in the Solar Industries Association now, we are going to develop some test briefing sessions of local Defense Department procurement officials in the regions of the U.S. where we have our af-

filiated State and regional chapters. Obviously we hope that by briefing these people, by answering their technical questions, by showing them what companies produce different kinds of solar technologies, that will open the door.

The problem is that, for an industry our size, and we are not very large, this is a mammoth task to brief all the local procurement officers just of the Department of Defense. We are not talking about GSA or HUD or anybody else. Just Defense I think would take us several years.

Therefore, I came before you today to ask that the House Science and Technology Committee work with us in some way of assisting industry, and maybe in concert with the House Armed Services Committee, to in some way institutionalize more concerted briefing sessions where we would be responsible to do it, but you open the doors or help speed the process up.

The other thing I wanted to ask the committee is that there is in this session, we found out in meeting with these procurement officials, that it is Defense Department practice to have our military facilities still rely on the electric grid. That is not only here, but abroad. Frankly, we were all a little bit shocked that with all the—there are a couple of GAO studies that I brought with me—that indicated that we were not able, either on the Federal or State level, to deal with a major electric disruption, that renewable energy, particularly photovoltaics and solar thermal technologies could be used as backup systems in the event of electrical shortages.

They all shook their heads and said that might be nice, but the fact of the matter is that is DOD policy, and we are going to rely on the conventional grid.

Again, I would like to ask this committee, and probably in concert with the House Armed Services Committee, to take a look at that policy of whether it is in our national interest to rely on the conventional grid system and, secondly, where alternative energy resources, obviously, particularly solar, would fit into that.

So, those are my two requests for the committee. I appreciate the opportunity to testify, and we will advise the staff on our progress in briefing these local procurement officers.

Thank you.

[The prepared statement of Mr. Sklar follows:]



Insert p. 46
Short

SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 520 1156 Fifteenth Street, NW Washington, D.C. 20005 (202) 293-2981

TESTIMONY BEFORE THE

HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

BY

SCOTT SKLAR
Director of Programs

Solar Energy Industries Association

ON

DEPARTMENT OF DEFENSE FEDERAL PROCUREMENT PRACTICES

SEPTEMBER 19, 1984



The Solar Energy Industries Association (SEIA) is the national trade association for the solar energy industry representing more than 200 solar manufacturers, distributors, dealers, installers, and component suppliers. Through our fourteen state and regional chapters with an additional aggregate membership of over 900 companies, and through our technical divisions, SEIA conducts a broad range of activities involving government policy, standards, research, marketing and other issues to build the solar industry.

Our association strongly supported Congressman Nicholas Mavroules' amendment to the Defense Authorization bill directing the Department of Defense to procure solar devices if cost effective. We believe that if the federal government made a concerted effort to purchase solar energy devices for space heating and water heating, and for the production of electricity through high temperature solar thermal and photovoltaics, the U.S. solar industry would be strengthened, and the federal utility bills paid for by the American tax payer would be lessened.

In federal buildings it is the American taxpayer that pays the utility bills. And for the life of the building, solar energy will surely provide a cost-effective reliable source of energy. This too is true with the solar electric technologies which have the capacity to supply a sure, non-disruptable supply of electricity. In a September 1982 study by the U.S. General Accounting Office titled, "The Federal Government is Still Not Adequately Prepared to Respond to Major Electrical Emergencies", they concluded that federal electrical emergency preparedness programs have not been developed, and that it may be difficult to manage and restore electrical power if a major disruption occurred because the States will not be able to deal with such incidents in a timely and effective manner.

Most of our military installations both inside and outside of the United States rely on the local electric grid. Because of a possibility of electric disruption from enemy attack, sabotage or from natural or manmade causes, the federal government has a responsibility to insure against long term disruption of electric power. Solar electric technologies provide a unique solution to these potential problems. Because of the national security benefits of solar utilization, coupled with the long term savings from solar thermal and electric technologies, the Solar Energy Industries Association (SEIA) strongly encourages the increased procurement of these devices on our federal buildings.

As a result of the passage of the Mavroules amendment, the Solar Energy Industries Association arranged a briefing this summer for the U.S. Department of Defense procurement officials at the Pentagon by representatives of the technical divisions of our association. Through the good offices of Mr. Milliard Carr of the Office of the Secretary of Defense, procurement officials from all the branches of the military received short briefings on active solar heating and cooling, solar hotwater thermosyphon systems, high temperature solar thermal, photovoltaics, solar rating and certification, and utility utilization of solar energy.

As a result of the interchange after the briefing, Department of Defense officials advised us that they have few technical concerns in regard to most of these solar technologies, and in fact, there was no discouragement for the procurement of these solar technologies on a case-by-case basis. However, we were also informed that decisions to procure any kind of building energy devices were made by the local procurement officers, not by the procurement officers at the Pentagon. We were advised that it would be to the solar industry's benefit to meet these people. Therefore, the Solar Energy Industries Association is planning

some test briefing sessions of local Department of Defense procurement officials in the states where we currently have SEIA-affiliated chapters. We hope that these educational briefing sessions for these local procurement officials will provide them with the kind of specific technical information that will open the procurement 'door' for solar technologies.

Unfortunately, this kind of effort to educate local procurement officers is a mammoth task for an industry the size of ours. Some kind of Defense Department program support in this area would be very useful. And I ask the House Science and Technology Committee to assist the solar industry by helping us secure some institutional assistance at the local level regarding procurement practices.

Another problem that the solar industry will have in garnering increased procurement of solar electric devices by the Department of Defense for use at military installations, is that the current Defense policy is set to continue our reliance on electric grid by our military installations rather than encouraging local electric production or substantial electric 'back-up' systems in the event of electrical shortages. Although we believe that this nation's military facilities ought to have solar electric systems as an insurance policy against power cut offs, there is no way to implement this approach if the military continues to rely on conventional power.

Clearly our military facilities abroad should have their own electric capacity since they are more vulnerable to both planned and natural disasters. On behalf of the U.S. solar industry, I ask both the House Science and Technology Committee and the House Armed Services Committee to jointly review this policy of reliance on the conventional grid system rather than on more reliable local energy sources such as solar energy.

The Solar Energy Industries Association (SEIA) is committed to work with the local Department of Defense procurement officers in hope that the bidding requests are open to solar systems. SEIA hopes that, if successful, we will be able to broaden procurement by other federal agencies such as the General Administration, and the Department of Housing and Urban Development. Many states now require that solar energy systems be considered in new buildings. Fannie Mae has just announced this year that they will increase the debt-to-loan ratio on homes that have energy conserving devices, such as solar energy. We hope that the federal government will take heed to the positive actions of state governments and other federal agencies in promoting the incorporation of solar energy devices. By doing so, the American taxpayer will be saved from paying larger and larger utility bills on federal buildings while simultaneously building a domestic solar energy industry.

Increased federal procurement of solar energy makes just good economic sense for both the taxpayer and the business community. I want to thank the Chairman and this Committee for your support of the U.S. Solar Energy Industry in this regard.

Mr. OTTINGER. Thank you, and thank you for a very useful and concise summary. I think your ideas are both worth pursuing.

The subcommittee will recess now for the vote, and we will be back in about 15 minutes.

Mr. SCHNEIDER. Mr. Chairman, if I might interject a 30-second comment, since I will be unable to return after this vote—

Mr. OTTINGER. The gentlelady is recognized.

Mrs. SCHNEIDER. I would recommend to Mr. Sklar that you approach the organization that I am the Chair of, and that is the Energy Environment Study Conference, made up of Members of Congress and the Senate and another group that I am involved with, the Military Reform Caucus. It might be possible to hold a joint meeting whereby we could then have briefings available for the procurement officers. I think that pulling those two organizations together would provide us with an appropriate forum.

Mr. SKLAR. I will do that with due speed. Thank you.

Mr. OTTINGER. All right. We will recess until right after the vote. [Short recess taken.]

Mr. OTTINGER. There is going to be another vote after this one, so we will get done what we can.

There has been a good deal of criticism of the AID program as it affects photovoltaics, particularly that it is too small and in cases like the Egypt program, very little money has actually gone to the

product and a lot is being made on paper studies and management contracts and that the AID officials are not adequately informed with regard to photovoltaics.

I wonder if you want to assess, just very briefly, the AID program for us and any recommendations that you might have to improve it.

Mr. ENFIELD. I don't know too much about the Egypt project, but I know a little bit. It is an ambitious project. From what I understand, they want to set up a technology monitoring process that can keep up with renewables over a period of years and, I guess, which would then have value to the Egyptians of keeping them up to date with the technology and allowing them to make procurements intelligently. That is actually a hardware system. It is a computer base system.

So, I think there is more to it than simply trying to identify the right systems to buy and then going out and buying them. I think they are really trying to equip the Egyptians to go into the renewable energy business. That, apparently, adds a lot of expense to it that won't show up in actual systems hardware but could be of value.

I guess one might ask whether that is the kind of function that AID in Egypt ought to play or whether that is the kind of function that AID's energy or AID's technical offices ought to play. If each country were to try to maintain a technology assessment program and a monitoring program, that could be pretty expensive. I would assume that AID in a central location ought to provide that service for the individual countries and just be more efficient overall. That is one perspective.

I think as far as the time that it has taken to get the thing going, there has been a lot of, I guess, organizational and perhaps personality problems on the Egypt end, shifting the thing around from one organization to another and shifting interests in the program. I think that has a lot to do with it, too.

I think that is about all I can say. Clyde, do you want to add something?

Mr. RAGSDALE. I am not specifically addressing the Egypt program, but there are two ways you could approach, through AID, the use of photovoltaics. One, as an energy resource, coming down from the top, saying this is an energy resource like hydro, like a fossil fuel system, et cetera, or you can look at it on a functional basis like it is part of an agricultural program which happens to have water pumping which does lend itself to PV in certain of the applications, et cetera. Therefore, it becomes an energy source as part of a functional program, much as a diesel generator would be considered or it is a power source for a remote medical center instead of a diesel generator, et cetera.

They are constantly putting together and funding programs of this nature, small programs like this in various of the developing countries. I think that just concentrating on the fact that PV is an applicable energy source for those kind of applications will do a lot for us, because, quite often, when we visit with the people in the field, they don't know the first thing about PV or its applicability for the kind of programs that we are talking about. Once they have become familiar with it, they get turned on to it. They think it is a

great idea and they can think, then, of many applications where it would be useful.

So, it is an educational program, I think, that is ultimately required.

Mr. OTTINGER. You think what we ought to do is have some kind of mandatory education of AID field people to make them acquainted with——?

Mr. RAGSDALE. I don't know how you do a mandatory education program, but a filter down program of some kind. Yes, I think some kind of an information, education program is important.

Mr. OTTINGER. What do you think about mandating the use of renewable energy wherever it is cost effective and making them actually do the calculations?

Mr. ENFIELD. I think if you get them to make the calculations, they would probably make the right decision. I think it is a question of their having the right information and the capability to choose among the options. That is what I think is lacking.

I think it is probably better to try to provide the information to the people who make the decisions. If then they don't make the right decisions, you take that next step. However, I don't think the system has worked well enough whereby the people in country really have the options well enough fleshed out for them to criticize them for not making the right decisions.

Mr. OTTINGER. Scott, do you have something——

Mr. SKLAR. No, I have nothing to add.

Mr. OTTINGER. On the question of the Government's procurements, you covered some of the questions that we had. Do you think that a mandate would be worthwhile, say that not only the Defense Department but the other agencies must purchase renewables if they are cost effective and must do the calculations?

Mr. SKLAR. Yes, I think a similar amendment to the Mavroules amendment across the board in Federal programs would be a great idea. I think at least it forces the decisionmakers to deal with the technology and, obviously, any program revolves, frankly, around the individuals within those positions of how open and, I must say again, at the national level and in Defense, the people have been very open, I think, on all levels to talk and to try to work something out. There is always resistance in the Federal Government, particularly by procurement guys, to say oh, one more regulation that is being forced on us. Clearly, it is almost like AID, an education process first. After education doesn't work, then maybe a little tougher incentive.

Mr. OTTINGER. What has been the industry's experience in setting up third party finance projects to sell energy to the Government?

Mr. SKLAR. One of the projects that has received a lot of attention is the Air Force Academy project. They will talk, I assume, about it later, but there have been a lot of delays of that project for months and months for various reasons, both on the local and by the national procurement staff. Some of that, I have been advised, also has some legal considerations. Could the Department of Defense accept basically a system financed by somebody else? I have been advised, frankly, today, that the legal concerns have been resolved.

That is one instance where it didn't jibe with what we were told in our briefing sessions. I was told no problem at the national level, it is all the local guys. Clearly, on the Air Force project, there has been as much delay on both the local and the national levels. One of our member companies which has produced that technology has just been sitting on the edge, getting promises that we are going to move forward tomorrow. It is sort of like the check is in the mail.

That clearly needs to be, I think, some questions asked by the Air Force representatives on what those steps, what those problems were. Maybe we can iron some of those out from a policy end.

Mr. OTTINGER. We heard 2 years ago from the industry that the Exim bank wasn't giving adequate attention at all to export markets for photovoltaics, largely due to their proclivity to take on huge projects and not having a proper mechanism for having to deal with smaller projects. Is that still the case today?

Mr. SKLAR. Sam, you would be best to answer that question.

Mr. ENFIELD. Well, again, I don't know too many cases where—I know of two companies that have approached Exim. One got a loan guarantee; the other didn't. And I don't know that scale or I don't know the reasons why the one company did not.

I think until we have more of a track record of companies not being served by the Bank, it is difficult to criticize the Bank. They have made great—made mention of their small business programs. None of their programs this year are terribly heavily used. I know some people have criticized the Bank for not promoting its resources as much as it could.

It is difficult to say, if companies aren't going in and using it. It may be that renewable energy projects are just simply too small to justify dealing with the Exim bank even from the company perspective, and I think Clyde might want to talk about that.

Mr. OTTINGER. We have had repeated problems, including the conference I went to a couple of years ago in Nairobi where our manufacturers felt they couldn't compete because of the preferred financing and subsidies that are given by other countries. In light of that, I am surprised to hear you say that the Exim resources weren't being adequately used.

Does that mean people aren't making applications to it or its assistance isn't significant enough to——

Mr. ENFIELD. At that last two opportunities that I have had to question the consultant that is doing our study for us, we have asked companies if they have gone to Exim and nobody has said that they have. So, we really haven't been able to find any photovoltaic companies that have used it.

Mr. OTTINGER. Why is that?

Mr. ENFIELD. I don't know.

Mr. RAGSDALE. I will answer that on behalf of our company. We have never gone to them because it has always been our understanding in discussions that we have had with them that they are looking only for large programs, and we have not been looking for large programs. We have been going after the small programs, the small development kind of programs. So, the opportunity has not presented itself for us to be either turned down or have an opportunity to negotiate with them. We have not taken advantage of it.

Mr. SKLAR. Just to add to that, the bias in the Bank has always been to large-scale. They have also looked for companies that have a long portfolio behind them. A lot of the solar industry does not have a long portfolio behind them. Many of these companies are new.

Finally, I think the problem with the solar industry traditionally has been that they do not all run, particularly the medium sized companies, to these Federal programs because they really don't know what they offer and they are afraid to get caught into the Federal bureaucracy and never found again. There needs to be some outreach, I think, by Eximbank on what they will do.

Mr. ENFIELD. I think that is valid. As I said, the people I know have criticized the Bank for not promoting its resources.

Solarex, the company that did get an Exim loan guarantee, only did so really because it is located in this area and someone who works at Solarex knows somebody who works at the Bank and thought, oh, I will call the Bank and see if they have anything. As it turns out, they did have something. Strangely enough, Solarex's bank had an open, \$0.5 million facility to Eximbank that it didn't even know about. So, Solarex managed to educate the Maryland National Bank about what it had available to it.

So, there is a real problem with people understanding what is available and then going after it.

Mr. OTTINGER. Is the financial assistance available through Eximbank comparable to that which other governments offer in terms of encouragement?

Mr. ENFIELD. Well, Japan, and German, and Holland, I guess, as I mentioned in my testimony, have real advantages because their domestic commercial interest rates are much lower.

Mr. OTTINGER. What I am asking is, the Eximbank, if you went to get it, is that comparable to what the Germans and the Japanese and the Dutch do?

Mr. ENFIELD. No, because Exim is not allowed to lend at rates substantially lower than the U.S. domestic rate. This is in international agreement.

So, by an agreement which we are party to, we are restricted from offering lower interest commercial rates. The Japanese, with a 5.5-percent prime rate, can offer commercial export rates very low and be very easily, comfortably within that agreement.

Mr. OTTINGER. I see.

Mr. ENFIELD. It is a free trade kind of agreement that we have reached internationally that works against us.

Mr. RAGSDALE. Another flavor, I think, that came out of our workshop the other day is the idea that on some of these foreign competitive activities, the intent and the desire is to stop them rather than to meet them. In other words, some of the remedies that we are taking are not to meet a competitive offer, if you will, but more to try to work with the other people to keep them from doing it and not get caught up in the same thing so that you have a competitive thing going on, competitive option market, if you will, on who has the best terms.

Mr. OTTINGER. All right.

We thank you very much for your help to the subcommittee and look forward to calling on you in the future.

We hear next from the Government agencies, Mr. William Sharkey, Director of the Energy and Transport Policy of the Department of Defense, accompanied by William D. Barnes, Director of Engineering and Construction of the U.S. Air Force Academy; and James Phillips, the Deputy Assistant Secretary for Capital Goods and International Construction of the U.S. Department of Commerce.

Gentlemen, as with the other witnesses, your full testimony will appear in the record. If you could summarize, we would appreciate it. We will start with Mr. Sharkey.

STATEMENT OF WILLIAM SHARKEY, DIRECTOR, ENERGY AND TRANSPORTATION POLICY, U.S. DEPARTMENT OF DEFENSE

Mr. SHARKEY. Thank you very much, Mr. Chairman.

Before we begin, I would like to mention that I have been running the energy programs at Defense for about 7 years which makes me a relative newcomer to the energy world compared to you, and I want to express my personal appreciation for the great work I have observed you do through the years in Congress and in energy, and best of luck in the future.

Mr. OTTINGER. Well, that is very nice. Thank you.

Mr. SHARKEY. I have with me today, as you said, Mr. Bill Barnes, who is the Air Force Academy engineering and construction supervisor. Also with me is Mr. Millard Carr from my staff on whom I rely for technical expertise.

I will summarize briefly my statement.

Before I do, there is one more thing I would like to mention. In my prepared text, I notice too late to delicately avoid it, we spelled Mr. Mavroules' name incorrectly, and we will take care to correct that before it gets into the record. We apologize.

Mr. OTTINGER. All right. He will forgive you.

Mr. SHARKEY. I might also mention that in his statement, there is a figure I would like to correct. He mentioned that DOD uses 81 percent petroleum to meet its needs. The number is roughly 67 or 68 percent, of which 7 or 8 percent of that is petroleum used to heat buildings on bases. The rest is for tanks, trains, planes, and that kind of material.

The Department of Defense has a very aggressive program in renewable energy, in all areas. I would like, just very briefly, to go through what some of those programs are.

First of all, an area that we are getting more and more benefit from is passive solar. We find that as new buildings are designed, virtually all of them are incorporating passive solar techniques. We feel that we are getting 15 to 25 percent savings from those techniques as compared to buildings that didn't have them.

We are working with the Department of Energy to learn how better to exploit passive energy in our analyses and our design work.

Active solar we have had kind of mixed experience with. We have about 140 projects which include 2,500 military family housing units on active solar, primarily domestic hot water units. We have had some successes and we have had some problems, design problems, maintenance problems, and the like.

We currently have Los Alamos Laboratories doing an analysis of our experience in active solar for us so that we can identify how we can improve in that situation. We are going to, based upon their work, develop an active solar energy system design handbook, and we are going to develop a family of fairly standardized solar systems.

In the wind area, we are finding the second generation wind machines very good. The Navy is testing three different kinds of machines at several locations, between 2 and 12 kilowatts each, with very good success so far. The Air Force, at Reese Air Force Base and at Ascension Island, are testing 25 kilowatt machines.

In biomass, we are burning refuse, we have for a long time down at Norfolk in the Public Works Center, and we are burning wood, we just recently started up a plant at Fort Stewart, GA. We are trying to put a refuse unit in the Philadelphia shipyard. We are having some local difficulties with environmental concerns.

In the geothermal area, we have two fairly large projects going in China Lake, CA, and Fallon, NV. We expect the geothermal to begin producing electricity sometime in 1985 in China Lake and in 1988 in Fallon. Each of those sites has the initial potential of up to 75 megawatts.

Finally, in terms of photovoltaics, that is an area where we have had, we believe, a lot of success through the years. We are very active participants in the FPUP program, the Federal Photovoltaic Utilization Program. We have about 218 systems that range from about 10 watts to 56 kilowatts. The Navy has developed, based upon largely FPUP experience, a photovoltaic user guide for design and selection, and we do have numbers of applications——

Mr. OTTINGER. Could you submit that to us for the record?

Mr. SHARKEY. Yes, sir, I will.

PHOTOVOLTAIC POWER SYSTEMS GUIDE

Answer. Material to be supplied for the record by Mr. Sharkey in response to Mr. Ottinger's request.

Flat Plate Photovoltaic Power Systems: Description, Design, and Cost

by

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Port Hueneme, Calif.

JULY 1982

**NAVAL WEAPONS CENTER
CHINA LAKE, CALIFORNIA 93555**



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FOREWORD

This report serves as a guide to identify applications suitable for photovoltaic systems as a power source. In addition, information is included to assist the design engineer in preparing a preliminary system design and in determining the cost-effectiveness of the overall system.

This work was funded by the Naval Civil Engineering Laboratory, Port Hueneme, Calif., under Department of the Navy Work Request No. N8830582WR90037. M. R. Hall is the primary author; G. D. Smith and D. L. Holmes provided technical information and assistance.

This report was reviewed for technical accuracy by Richard D. Fulmer.

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(U) *Flat Plate Photovoltaic Power Systems: Description, Design, and Cost*, by Michael R. Hall, Garyl D. Smith, and David L. Holmes. China Lake, Calif., Naval Weapons Center, July 1982. 116 pp. (NWC TP 6381, publication UNCLASSIFIED.)

(U) The Energy Program Office at the Naval Weapons Center has been tasked to manage the Department of the Navy's photovoltaic effort. This effort includes participation in the Federal Photovoltaic Utilization Program (FPUP), which is sponsored by the Department of Energy, and encouragement of worldwide Navy activities to use Navy funds to procure cost-effective photovoltaic power systems.

(U) This report describes in simple nontechnical terms what photovoltaic power systems are, how they are sized, their costs, and their advantages and disadvantages. It also includes all tables and information necessary for the nontechnical person to determine preliminary sizes and costs of photovoltaic power systems for most applications. Navy activities can identify cost-effective applications for photovoltaic power systems by using this report and can procure the systems on their own or seek assistance from the Energy Program Office. The Energy Program Office will assist in preparing procurement specifications, evaluating proposals, awarding and monitoring contracts, and acceptance-testing the systems.

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CONTENTS

Introduction	3
Photovoltaic Power System Description	3
Photovoltaic Array Sizing	10
Battery Storage Sizing	14
Photovoltaic Power System Cost Analysis	17
Conclusions	24
Bibliography	27
Appendixes:	
A. Equations and Worksheets for Photovoltaic Power System Sizing and Cost Analysis	29
B. Photovoltaic Power System Load Identification, System Sizing, and Costing Example	37
C. Photovoltaic Module Specification Sheet	53
D. Average Daily Solar Insolation Tables	55
E. Storage Battery Specification Sheet	97
F. Inflation-Discount Factors	99

NWC TP 6381

INTRODUCTION

The Naval Weapons Center (NWC) has been involved in photovoltaic development since 1974 and was designated lead laboratory for the Department of the Navy's photovoltaic program in December 1978. Initial effort as lead laboratory was to coordinate the Navy's participation in the Federal Photovoltaic Utilization Program (FPUP) and to transfer the emerging photovoltaic technology from the research and development area to the user community. The goal of the Navy photovoltaic program is to use photovoltaic systems where they are cost-effective. In order to reach this goal, it is necessary to have the support of Navy activities.

This report serves as a guide to identify applications suitable for photovoltaic systems as a power source. In addition, the report contains information to assist the design engineer in preparing a preliminary system design and in determining the cost-effectiveness of the overall system.

The goal of the FPUP, a program funded by the Department of Energy (DOE), is to stimulate the photovoltaic industry by creating a demand for photovoltaic power systems. By creating the demand, DOE anticipates that the cost of photovoltaic power will be reduced so that applications will become cost-effective enough to keep up the demand. As the demand increases for photovoltaic power, the costs will decrease. Costs have been reduced under FPUP, and as they are reduced, more and more cost-effective applications are being identified.

FPUP, a multiyear program, is almost complete. No more applications are being accepted for funding under FPUP, and it is now time for the Navy to purchase photovoltaic power systems with Navy funds. The Navy photovoltaic program has developed skills in the procurement and installation of photovoltaic power systems under FPUP. NWC will continue to use its skills by assisting any Navy activity that wishes to procure a photovoltaic power system in preparing contract specifications, evaluating proposals, awarding and monitoring contracts, and acceptance-testing the systems. Assistance can be obtained by calling Michael Hall on AUTOVON 437-3411, extension 241, or commercial (619) 939-3411, extension 241.

PHOTOVOLTAIC POWER SYSTEM DESCRIPTION

The major elements of a photovoltaic power system for a stand-alone (nonutility-grid-connected) application are solar array modules, either concentrating or flat plate; rechargeable batteries; and a voltage regulator. For loads requiring an alternating current (AC), an inverter is required to convert the photovoltaic-generated direct-current (DC) power to AC power.

There are several types of concentrator solar arrays, and they all require either one- or two-axis sun-tracking mechanisms. The concentrator solar cell geometry is designed with multiple grid patterns to reduce the high cell losses that develop when the cell is subjected to high solar intensities. In addition, the cell temperature must not exceed 140°C . The cell temperature is controlled by mounting the solar cell on a pipe through which a coolant is circulated at a controlled rate to remove excess heat. A design used on passive concentrator collectors employs metal fins for heat rejection.

Flat plate modules have been widely used throughout the world during the last 10 years. Flat plate solar collectors do not require sun-tracking mechanisms. The collectors are oriented at a fixed tilt angle at the time of installation. To optimize performance, simple seasonal adjustment is made in the tilt angle.

Due to the extensive past experience, reliability, and simplicity of design, this report is concerned only with flat plate modules for stand-alone photovoltaic power systems. Figure 1 depicts a typical photovoltaic system using a flat plate solar array.

A photovoltaic power system captures solar radiation, converts it directly to DC electricity, conditions the DC electricity to supply the application load with the required power (e.g., 115 VAC, 60 Hz), and stores any excess power for use on cloudy days or at night.

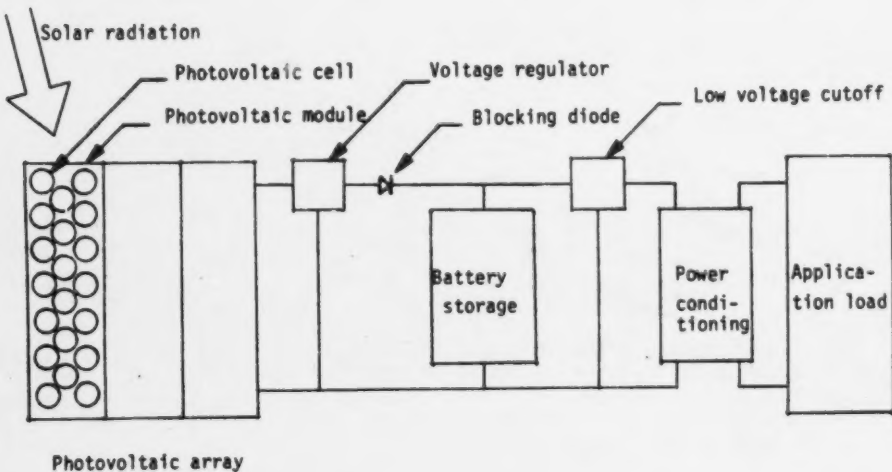


FIGURE 1. Photovoltaic Power System.

Photovoltaic Cell

The photovoltaic cell, also known as a solar cell, is the power source for the system. The cell, which converts solar radiation directly into electricity, is made of a semiconducting material with chemical additives used to produce a pn junction near the surface of the material. Solar radiation reaches the earth in discrete amounts of pure energy called photons. When the photons hit the pn junction near the surface of the material, the photon's energy is used to produce a positive and a negative charge. The charges would recombine if it were not for the pn junction, which acts as a barrier and keeps the charges apart. The positive charges collect on the p-side of the junction and the negative charges collect on the n-side, creating a voltage potential across the junction. When electrical contacts are added to the p-side and n-side of the solar cell, this separation of charges can be used to supply power to an external load. The photovoltaic cell can be considered a "solar battery." Like a battery, the cell has positive and negative terminals and will supply power when connected to an external load. Unlike a battery, the cell cannot store energy, but only supplies energy when exposed to solar energy. The cell is, in effect, a constant-voltage DC generator. Figure 2 shows the construction and operation of a photovoltaic cell.

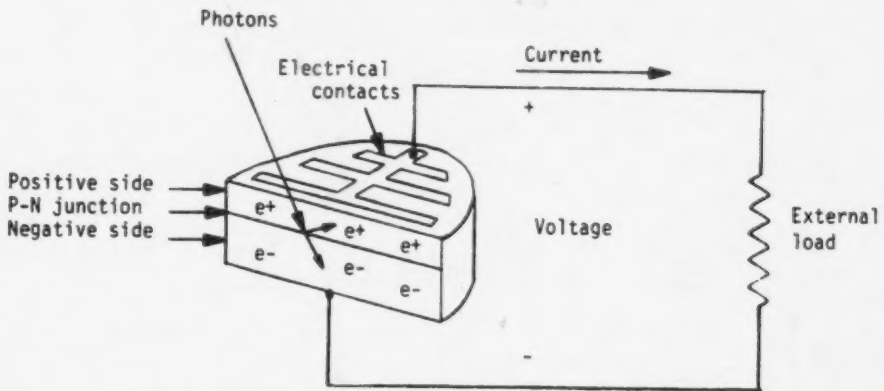


FIGURE 2. Construction and Operation of a Photovoltaic Cell.

The most common and commercially available photovoltaic cells are fabricated from single-crystal silicon ingots grown from semiconductor-grade polycrystalline silicon. The polycrystalline material is melted (together with controlled amounts of impurities) in a quartz crucible and grown from small "seed" crystals that are inserted into the melt and rotated as they are slowly withdrawn from the melt. Typically ingots 3 or 4 inches in diameter and 12 inches in length are grown by this process. The completed ingot is then sliced into wafers that are 10 to 15 mils thick. The wafers are chemically treated to remove defects. The pn junction is normally formed by gaseous diffusion of phosphorous. Electrical contacts are placed on the front and back side of the cell by a variety of techniques, including silk screening and evaporation of silver or other materials.

The photovoltaic cell current is primarily dependent on the amount of solar radiation striking the cell and the exposed cell area. The voltage produced is primarily dependent on the cell temperature. To compare photovoltaic cells from different manufacturers, it is necessary to state the different cell output characteristics under standard conditions of solar radiation and temperature. The photovoltaic industry has agreed to use the following conditions as Standard Test Conditions:

solar radiation striking the cell = $100 \text{ mW/cm}^2 = 1 \text{ kW/m}^2 (317 \text{ Btu/h}^\circ\text{F})$

cell operating temperature = approximately $27^\circ\text{C} (80^\circ\text{F})$

Figure 3 shows the typical output of a 3-inch-diameter silicon solar cell under Standard Test Conditions. The cell output is also shown normalized to indicate at what operating point the maximum power is supplied by the cell.

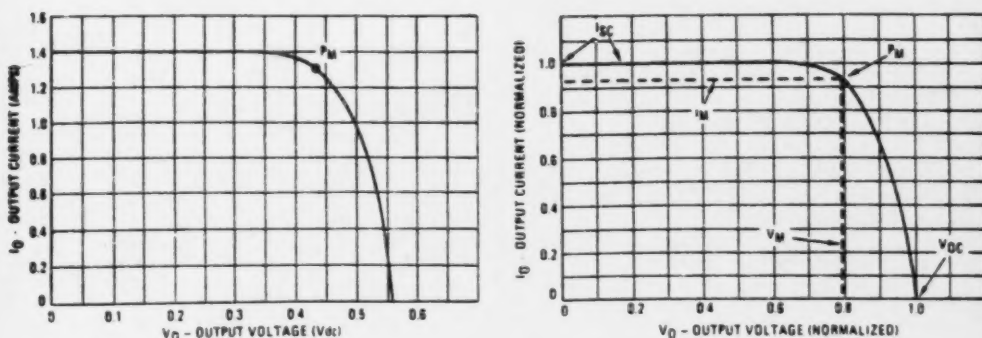


FIGURE 3. Typical 3-Inch Silicon Photovoltaic Cell Characteristic Curves.

When the cell's electrical contacts are shorted, the output voltage is zero, and the cell supplies the maximum amount of current physically possible. This is the short circuit current (I_{SC}). When the electrical contacts are opened, the cell will be forced to provide the highest voltage possible. This is the open circuit voltage (V_{OC}). The operating voltage, current, and power (power = volts $\times$ amperes) supplied by the cell to an external load will depend on the external load's electrical resistance. The photovoltaic cell's operating point will lie on the characteristic curve, and the cell will supply the maximum power to the load at the maximum power point (P_M) on the characteristic curve. The maximum power will be supplied when the load voltage is approximately 80% of the open circuit voltage. Figure 4 shows how the short circuit current, open circuit voltage, and maximum power point change with varying solar radiation intensities and cell temperatures.

As stated earlier, the photovoltaic cell acts like a battery because the cells can be connected in series to increase system output voltage or in parallel to increase system output current (Figure 5). When photovoltaic cells are connected in series, their output current is the same as for a single cell. When cells are connected in parallel, their output voltage is the same as for a single cell.

NWC TP 6381

TABLE 1. Types of Lead-Acid Batteries.

BATTERY TYPE		ENERGY COST	ENERGY DENSITY	CHARACTERISTICS
		rated \$/kWh	rated Wh/lb	
SLI	AUTO	\$25-54	15-21	High self-discharge; shallow discharge cycle; short life under deep discharge conditions
	DIESEL	\$50	18-18	
MOTIVE	GOLF CART TYPE	\$45-80	30-35	250 cycle life; high self-discharge; deep cycle
POWER	LONG LIFE	\$180-220	7-11	1,000-2,000 cycle life; high self-discharge; deep cycle
FLOAT	PURE LEAD GRID	\$80-130	14-18	Low self-discharge; low maintenance
SERVICE	LEAD-CALCIUM	\$180-240	7-10	1,500 cycle life; low self-discharge; deep cycle capabilities
SEALED	FLOAT SERVICE	\$140	14-18	Low maintenance; low self-discharge

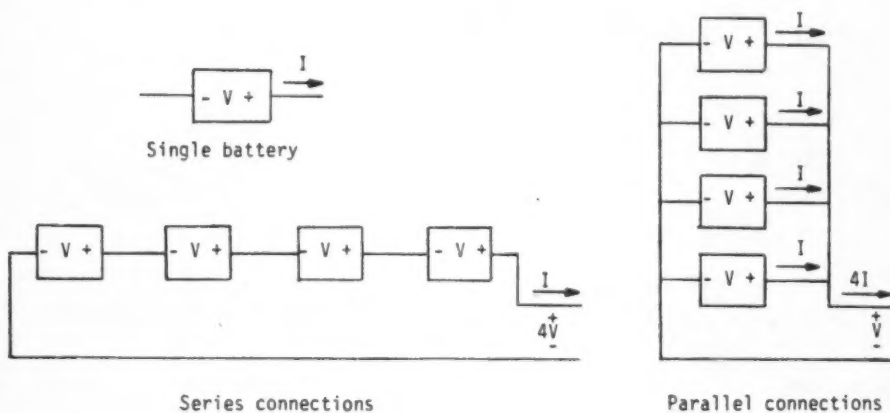


FIGURE 6. Series and Parallel Battery Connections.

Power Conditioning

The power-conditioning unit converts the power from the photovoltaic array or the battery storage to the type and quality of power required by the load. The power conditioning unit can be as simple as a voltage regulator or DC-to-DC converter, or as complex as a three-phase sine-wave inverter.

Application Load

The application load is the equipment that receives its power from the photovoltaic power system.

NWC TP 6381

All photovoltaic power systems contain a photovoltaic array and an application load, but not necessarily a voltage regulator, blocking diode, battery storage, or a power conditioning unit. A properly designed photovoltaic power system for water pumping requires only the photovoltaic array and the application load. A voltage regulator is not needed if the pump motor can handle the photovoltaic array's voltage swing, and a water storage tank eliminates the need for battery storage. The components needed for a given application are determined by the requirements of the application load.

PHOTOVOLTAIC ARRAY SIZING

The photovoltaic power system functions as follows: The application load operates from the battery storage, and the photovoltaic array keeps the battery storage charged. In sizing the photovoltaic power system, the battery storage is sized to meet the load power requirements, and the photovoltaic array is sized to keep the battery storage charged. Appendix A contains all equations necessary to size photovoltaic power systems and includes a sizing worksheet to make system sizing easier.

The primary parameter in system sizing is the load power requirements, which must be accurately known. A useful photovoltaic power system cannot be properly sized without accurate load power requirements. Appendix B thoroughly covers the determination of load power requirements. Once these requirements are identified, the load (for sizing purposes) can be calculated using Equation 1.

$$\text{load (Wh/day)} = \frac{\text{duty cycle (Wh/day)}}{\text{power conditioning efficiency (decimal)}} \quad (1)$$

where

load (Wh/day) = the amount of power the photovoltaic power system must supply in watthours per day.

duty cycle (Wh/day) = the application instantaneous power draw times the number of hours per day the power is being drawn. If the power is used only part of the week, average it out over the entire week. If an application has more than one duty cycle, sum all of the duty cycles and enter the total in Equation 1. Duty cycle is in units of watthours per day.

power conditioning efficiency (decimal) = the efficiency in decimal form of the inverter or DC-to-DC converter. If there is no inverter or DC-to-DC converter, enter 1.0.

A complete example of the use of this sizing technique is included in Appendix B.

Photovoltaic modules used in stand-alone photovoltaic systems are designed to work well with battery storages. Batteries require a higher voltage during charging than they exhibit when they are providing power. For instance, a 12-volt battery needs a little more than 14 volts to be charged properly while it supplies power at 12 volts. Photovoltaic modules come in

NWC TP 6381

connected in series. Modules are easier to handle and quicker to install than single cells. Like photovoltaic cells, modules can be connected in series for a higher system output voltage or in parallel for a higher system output current. A module is electrically no more than a preassembled block of cells and functions to protect the cells from the environment. The module is a sandwich of a superstrate (usually tempered glass), an encapsulant, photovoltaic cells, and a substrate laminated together under pressure and temperature. The lamination protects the cells from damage due to hail, wind, moisture, dirt, and handling.

Photovoltaic Array

The photovoltaic array is the entire field of modules connected in series and in parallel and mounted on a support structure.

Voltage Regulator

The voltage regulator adjusts the output voltage from the array to protect the battery storage. The regulator sets the charging voltage to maximize battery charging and at the same time acts to limit battery water loss from gassing due to battery overcharging.

Blocking Diode

The blocking diode prevents the battery storage from discharging through the voltage regulator or the photovoltaic array at night or on cloudy days.

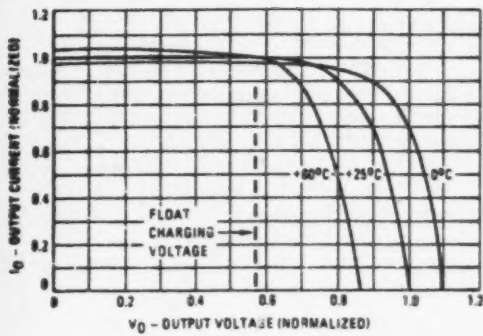
Battery Storage

The battery storage is used to store energy produced by the array and not used by the load, and also to supply power to the load at night and on cloudy days. The ideal storage battery for a photovoltaic power system must hold a charge (have a low self-discharge) for an extended period of time. The battery must be able to survive a number of cycles of deep discharge and subsequent recharge, and must also have a long life with very little maintenance. The most commonly used storage battery is the lead-acid battery. In Table 1, the different types of available lead-acid batteries are compared; float service, pure lead, or lead-calcium batteries best meet all of the requirements for a photovoltaic power system battery storage.

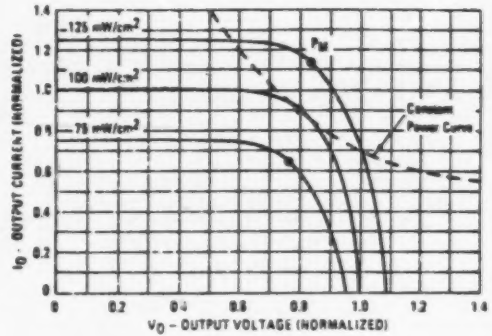
Storage batteries are connected in series to increase the battery storage voltage and in parallel to increase the battery storage current. The current supplied by a series string of batteries will be the same as the current supplied by a single battery. The voltage supplied by parallel-connected batteries will be the same as the voltage supplied by a single battery. Figure 6 shows series and parallel battery connections.

Low-Voltage Cutoff

A low-voltage cutoff is used to disconnect the battery storage from the load to prevent damage to the batteries when being discharged too deeply.



Varying Temperature



Varying Solar Radiation Intensity

FIGURE 4. Effects of Varying Temperature and Solar Radiation Intensity on a Typical Photovoltaic Cell Characteristic Curve.

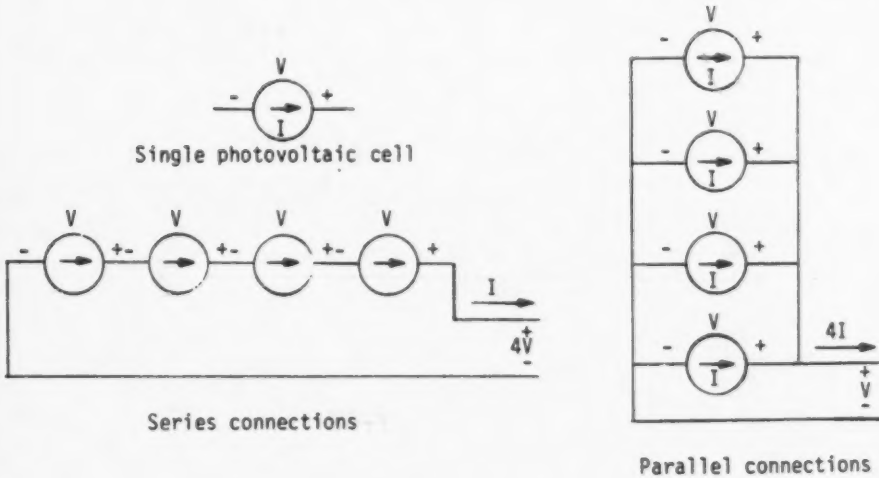


FIGURE 5. Photovoltaic Cell Series and Parallel Connections.

Photovoltaic Module

Virtually all photovoltaic power systems require power at a higher output than a single photovoltaic cell. Individual cells are assembled into photovoltaic modules because mounting single cells would be time-consuming and tedious. The modules usually contain 36 to 40 cells

NWC TP 6381

fairly standard voltages to supply the required higher charging voltage. A 16-volt module is designed to provide the proper charging voltage for a 12-volt battery. The 16-volt module output is necessary to provide the higher charging voltage the battery requires and to provide for voltage losses in the photovoltaic power system. Photovoltaic modules are connected in series to increase the photovoltaic system voltage. Equation 2 is used to determine the number of photovoltaic modules required to charge a given battery storage (see example in Appendix B).

$$\frac{\text{number of series photovoltaic modules}}{\text{}} = \frac{\text{nominal battery storage voltage (VDC)}}{\text{nominal photovoltaic module voltage (VDC/module)}} \quad (2)$$

where

nominal battery storage voltage (VDC) = the DC operating voltage level of the battery storage.

nominal photovoltaic module voltage (VDC/module) = the operating voltage of the battery that the photovoltaic module is designed to charge (e.g., a 16-volt photovoltaic module is designed to charge a 12-volt battery; the nominal voltage of the 16-volt module is 12 volts). The nominal photovoltaic module voltage is usually supplied on the module specification sheet (Appendix C).

If the results of Equation 2 contain a fraction of a module, round the number of series photovoltaic modules up to the next whole number (e.g., 8.4 photovoltaic modules is rounded up to 9).

Photovoltaic modules are connected in parallel to supply the current requirements of the application load. Equation 3 is used to determine the number of parallel modules necessary to supply the current requirements of a specified application load. Equation 3 must be solved for each month, and the largest answer must be used in the balance of the photovoltaic array sizing. Using the largest answer from Equation 3 ensures that the application load will be met by the photovoltaic system throughout the year (see example in Appendix B).

$$\frac{\text{number of parallel photovoltaic modules}}{\text{}} = \frac{\text{load (Wh/day)} \times 1.20}{\frac{\text{nominal battery storage voltage (VDC)}}{\text{}} \times \frac{\text{equivalent peak hours per day (h/day)}}{\text{}} \times \frac{\text{nominal photovoltaic module current (A/module)}}{\text{}}} \quad (3)$$

where

load (Wh/day) = result of Equation 1.

1.20 = a 20% safety factor to account for photovoltaic-array output degradation due to age and dirt.

nominal battery storage voltage (VDC) = the DC operating voltage level of the battery storage.

equivalent peak hours per day (h/day) = the equivalent hours per day that the photovoltaic array receives solar radiation at a level of 100 mW/cm^2 as specified in the Standard Test Conditions (discussed earlier under the heading, "Photovoltaic Cell"). The equivalent peak hours per day is computed by taking the total amount of solar radiation received by the surface of the array in a day and dividing it by the solar radiation level of 100 mW/cm^2 as specified in the Standard Test Conditions. This calculation provides the number of hours that the array would have to be exposed to the Standard Test Condition of 100 mW/cm^2 to receive the same amount of energy that the array received during the day.

The amount of solar radiation received by the surface of the array depends on the tilt angle of the array and the amount of solar radiation received by a horizontal surface at the array location. The horizontal solar radiation at a specific location (which includes weather effects), is usually found in all solar energy source books. The tilt angle of the photovoltaic array determines what amount of the horizontal solar radiation will be received by the tilted array surface. As a surface is tilted to the south, it receives more energy in the winter and less energy in the summer. Figure 7 shows the solar radiation received by a surface that is tilted 20, 35, and 50 degrees

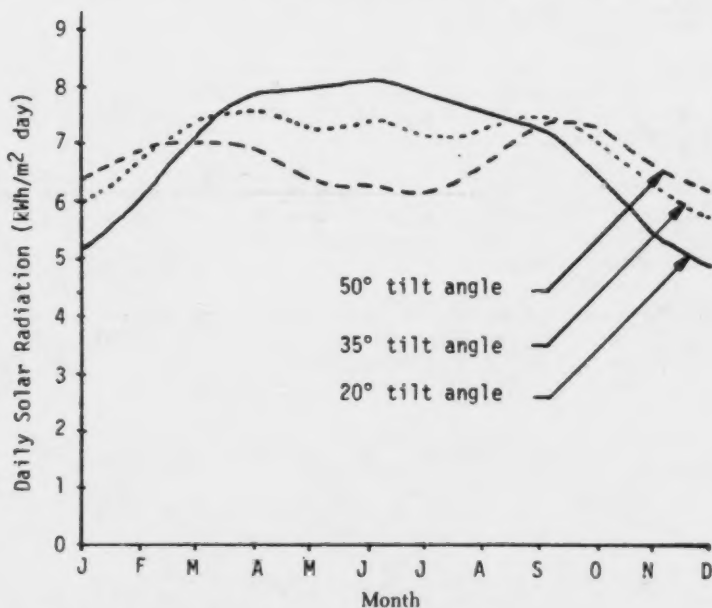


FIGURE 7. Solar Radiation Received by a Surface That is Tilted at 20, at 35, and at 50 Degrees From the Horizontal at Albuquerque, N. Mex.

from the horizontal for Albuquerque, N. Mex. Figure 7 also shows that the amount of available solar radiation received by the photovoltaic array can be varied by adjusting the tilt angle.

The determination of the proper tilt angle for a photovoltaic power system depends on how the load power requirements compare to the solar radiation received by the tilted array surface. For constant year-round load requirements, the tilt angle should be adjusted so that the amount of energy received in the winter is as close as possible to the amount of energy received in the summer. For load requirements that vary from month to month, the tilt angle should be selected that best matches the yearly load profile to the profile of the yearly solar energy received. Once the tilt angle is selected, the equivalent peak hours per day can be determined.

The amount of solar radiation received by a tilted surface is very complicated to calculate. Appendix D contains tables of solar radiation received on a tilted surface for three common tilt angles for a number of cities. Equivalent peak hours per day can easily be determined by locating the table of solar radiation on a tilted surface for a city nearest the photovoltaic array location and dividing by 100 mW/cm^2 (1 kW/m^2). Values of equivalent peak hours per day are the same as the values of daily solar radiation given in units of kWh/m^2 .

nominal photovoltaic module current (A/module) = the nominal module current output that is usually supplied on the module specification sheet (Appendix C). The nominal module current output is also designated as module test current, module current at peak power point, and module current.

The number of parallel photovoltaic modules should be rounded up to the next higher whole number if a fraction of a module results from Equation 3.

The total number of modules needed for the power system is equal to the number of series photovoltaic modules times the number of parallel photovoltaic modules. A photovoltaic array is most often defined and purchased in terms of peak watts. Peak watts is the power the array would supply when exposed to Standard Test Conditions. The total peak watts of an array are defined in Equation 4 (see example in Appendix B).

$$\begin{array}{lcl} \text{total peak} & \text{number of series} & \text{number of parallel} & \text{peak watts per} \\ \text{watts (W)} & = \text{photovoltaic} & \times \text{photovoltaic} & \times \text{photovoltaic} \\ & \text{modules} & \text{modules} & \text{module (W)} \end{array} \quad (4)$$

where

number of series photovoltaic modules = the results of Equation 2.

number of parallel photovoltaic modules = the results of Equation 3.

peak watts per photovoltaic module (W) = peak watts supplied on the module specification sheet (Appendix C). Peak watts is also known as peak power.

BATTERY STORAGE SIZING

The battery storage is designed to provide the load with a continuous supply of power (1) for nights, (2) for a specified number of sunless days, and (3) to increase system reliability. The designed battery storage size is found by solving Equation 5 for each month to determine the largest required storage size. The largest answer from Equation 5 must be used in the balance of the battery storage sizing (see example in Appendix B).

$$\frac{\text{designed battery storage size (Wh)}}{\text{load (Wh/day)} \times 1.20 \times \text{required days of storage (day)}} = \frac{\text{depth of discharge (decimal)}}{\text{depth of discharge (decimal)}} \quad (5)$$

where

load (Wh/day) = load calculated in Equation 1.

1.20 = a 20% safety factor that compensates for storage degradation due to age.

required days of storage (day) = the number of consecutive sunless days the photovoltaic power system must operate. This number will be at least 1 and should be determined from weather information for the photovoltaic power system location.

depth of discharge (decimal) = the allowable depth of discharge that prolongs battery storage life and prevents the battery storage from freezing. Discharging a battery 100% will greatly shorten the storage battery life. In applications that are subject to freezing, sufficient battery storage capacity must remain to prevent the battery storage from freezing. Figure 8 shows a typical battery design curve and provides the information necessary to determine the allowable battery storage depth of discharge. Determine the minimum temperature the battery storage would be likely to experience and, from Figure 8, find the allowable depth of discharge that corresponds to this temperature. The depth of discharge must be in decimal form (80% = 0.80) and should be no greater than 0.80.

The number of series-connected batteries is calculated by Equation 6 (see example in Appendix B).

$$\frac{\text{number of series batteries}}{\text{nominal battery storage voltage (VDC)}} = \frac{\text{nominal single battery voltage (VDC/battery)}}{\text{nominal single battery voltage (VDC/battery)}} \quad (6)$$

where

nominal battery storage voltage (VDC) = the DC operating voltage level of the battery storage.

nominal single battery voltage (VDC/battery) = nominal single battery voltage supplied on the product specification sheet. See Appendix E for a sample specification sheet.

The number of series batteries should be rounded up to the next higher whole number if a fraction results from Equation 6.

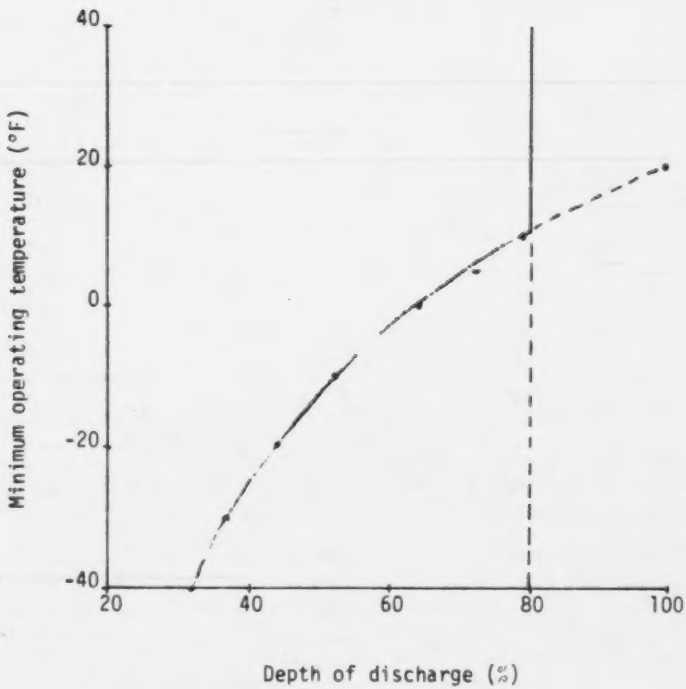


FIGURE 8. Battery Storage Depth of Discharge as a Function of Battery Storage Minimum Operating Temperature.

The number of batteries required to be connected in parallel is calculated by Equation 7 (see example in Appendix B).

$$\text{number of parallel batteries} = \frac{\text{designed battery storage size (Wh)}}{\text{nominal battery storage voltage (VDC)} \times \text{nominal ampere hours per battery (Ah/battery)}} \quad (7)$$

where

designed battery storage size (Wh) = result of Equation 5.

nominal battery storage voltage (VDC) = the DC operating voltage level of the battery storage.

nominal ampere hours per battery (Ah/battery) = the ampere hour capacity of the selected storage battery. The ampere hour capacity depends on the discharge current.

NWC TP 6381

Higher discharge currents provide for lower ampere hour capacities for the same battery. The ampere hour capacity should be selected for the average battery discharge current. If this value cannot be determined, use the design ampere hour capacity supplied on the battery specification sheet (Appendix E).

The number of parallel batteries should be rounded up to the next higher whole number if a fraction results from Equation 7.

The actual battery storage size is calculated from Equation 8 (see example in Appendix B).

$$\text{actual battery storage size (Wh)} = \frac{\text{number of series batteries} \times \text{number of parallel batteries} \times \text{nominal ampere hours per battery (Ah)} \times \text{nominal single battery voltage (VDC)}}{\quad} \quad (8)$$

where

number of series batteries = result of Equation 6.

number of parallel batteries = result of Equation 7.

nominal ampere hours per battery (Ah) = the design ampere hour capacity of the battery.

The design ampere hour capacity is supplied on the battery specification sheet (Appendix E).

nominal single battery voltage (VDC) = nominal single battery voltage supplied on the battery specification sheet (Appendix E).

Actual battery storage size is often discussed in terms of kilowatthours of storage capacity. Divide watthours by 1000 to convert to kilowatthours.

The battery storage must be able to supply the peak battery current requirement of the load. The ability of the battery storage to meet the peak battery current requirement can be determined by the following steps.

Step 1. Calculate the peak battery current requirement in amperes by using Equation 9 (see example in Appendix B).

$$\text{peak battery current requirement (A)} = \frac{\text{peak load power requirement (W)}}{\text{nominal battery storage voltage (VDC)} \times \text{number of parallel batteries}} \quad (9)$$

where

peak load power requirement (W) = the largest load power requirement in watts divided by the inverter efficiency, if any (in decimal form).

nominal battery storage voltage (VDC) = the DC operating voltage level of the battery storage.

number of parallel batteries = result of Equation 7.

NWC TP 6381

Step 2. Use the peak battery current requirement from Equation 9 and the battery design curve (Appendix E) to determine the number of hours the peak battery current can be supplied by the battery. Be sure to adjust the design curve to the minimum operating temperature of the battery storage.

Step 3. Check to be sure that the number of hours the peak battery current can be supplied is sufficient to meet the load duty cycle for the peak load power requirement of Equation 9 times the required days of storage.

Step 4. If the battery cannot supply the peak battery current requirement for the load duty cycle in step 3, add additional parallel strings of batteries to the battery storage and go back to step 1. When sufficient parallel battery strings have been added to meet the peak battery current requirement, recalculate Equation 8 using the new number of parallel battery strings.

PHOTOVOLTAIC POWER SYSTEM COST ANALYSIS

Photovoltaic power systems are cost-effective and should be purchased when the life-cycle cost of the photovoltaic power system is less than the life-cycle cost of the competing conventional power source. The competing power source may be diesel generators, batteries, or the extension of a distant utility grid. Life-cycle costs indicate the amount of money needed today to cover the cost of the system throughout its economic life. These costs include one-time capital, operating, and maintenance costs that are adjusted for the effects of inflation and interest rates. Cost work sheets in Appendix A are used to help in making the cost analysis.

The one-time capital costs for a photovoltaic power system include costs for initial purchase, installation, and future battery replacement. The yearly operating and maintenance costs include checking battery and photovoltaic array conditions. The estimated life of a photovoltaic power system is 25 years with the batteries being replaced every 10 years.

The one-time capital costs for a diesel generating power system include the cost of the diesel generators and the fuel storage system. The yearly operating and maintenance costs include diesel maintenance and fuel costs. The estimated life of a diesel generator is 25 years.

The one-time cost for a battery power source is the initial and future replacement costs of the battery. The operating and maintenance costs include checking and recharging the battery. The estimated life of a battery energy source is 10 years.

The one-time cost for an extended utility grid power source is the cost of extension. The operating and maintenance costs include energy costs and line- and transformer-inspection costs. The estimated life of a utility grid is 25 years.

Figure 9 shows the relative cash flows for the photovoltaic power system and the three alternate power sources. The cash flows show how money will be spent on the power source throughout its economic life. The displayed values are taken from the example in Appendix B.

Calculating life-cycle costs involves more than simply adding up the cash flows in Figure 9. Because of inflation and interest rates, \$1 in the future will not be equal to \$1 today.

NWC TP 6381

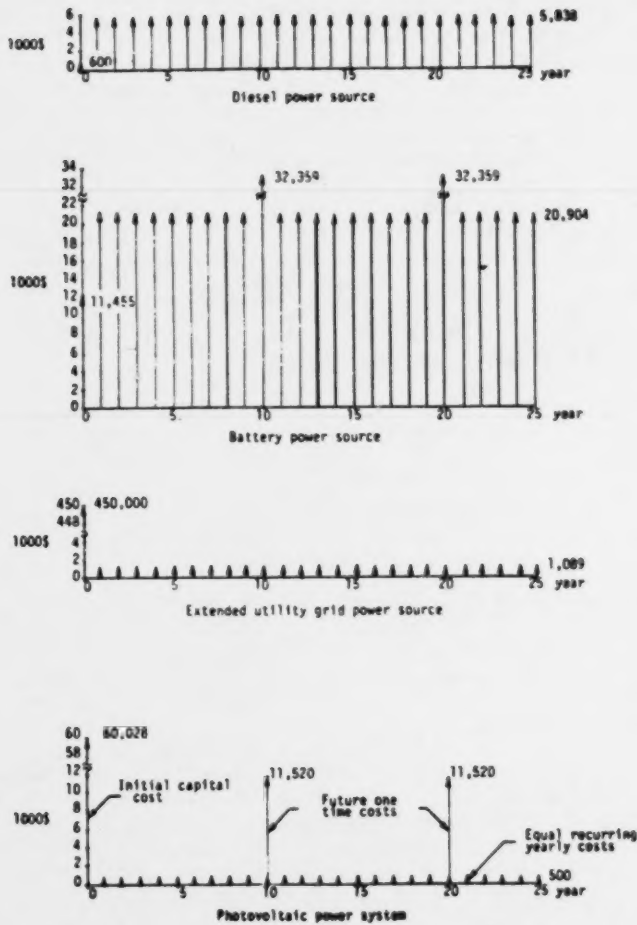


FIGURE 9. Relative Cash Flow Diagrams for Four Power Sources.

This changing value of future money is known as the time value of money. One dollar invested at 7% interest will be worth \$1.07 in 1 year and \$1.145 in 2 years. One dollar today will be worth more in the future, and likewise, if \$1 will be needed in the future, less than \$1 is needed to be invested today. Inflation works the same way except that money shrinks in value instead of growing.

The combined effects of interest and inflation on the time value of money have been conveniently computed in the tables in Appendix F. These tables show inflation-discount factors and will give the present (today's) value of future costs. The Differential Inflation Rate

is used when the price of the energy source being evaluated (for example, gasoline) has a higher inflation rate than the general economy. The discount rate is the interest rate the Navy assumes for economic analysis. The single-amount discount factor is used to determine the present value of a one-time future cost that is calculated by multiplying the future cost by the single-amount factor for the project year in which the cost occurs. The proper table to use is determined by the Differential Inflation Rate. The cumulative-uniform-series discount factor is used to determine the present value of an equal recurring yearly cost. For applications that use the same amount of energy each year, the annual fuel cost would be an equal recurring yearly cost. The present value of an equal recurring yearly cost is calculated by multiplying the equal recurring yearly cost by the cumulative-uniform-series discount factor corresponding to the number of years the equal recurring yearly cost will occur (usually the economic life of the system).

Equation 10 is used to determine the life-cycle cost, or present value, of any of the four energy sources (see example in Appendix B).

$$\begin{aligned} \text{life-cycle cost} &= \text{initial one-} + \text{future one-} \times \text{single-amount} \\ \text{(present value) (\$)} &= \text{time cost (\$)} + \text{time cost (\$)} \times \text{discount factor} \\ &+ \text{equal recurring} \times \text{cumulative-uniform-} \\ &\text{yearly costs (\$)} \times \text{series discount factor} \end{aligned} \quad (10)$$

where

initial one-time cost (\$) = initial cost of the power source.

future one-time cost (\$) = cost of one-time future expenses. Battery replacement would be a future one-time cost at years 10 and 20. If more than one future one-time cost occurs, multiply it by the appropriate single-amount discount factor and add the result to Equation 10.

single-amount discount factor = that obtained from the appropriate Differential Inflation Rate table in Appendix F. Select the single-amount discount factor corresponding to the year of the future one-time cost.

equal recurring yearly costs (\$) = costs that are the same and occur from year to year. Fuel costs and operating and maintenance costs are usually equal recurring yearly costs.

cumulative-uniform-series discount factor = that obtained from the appropriate Differential Inflation Rate table in Appendix F. Select the cumulative-uniform-series discount factor corresponding to the number of years the equal recurring yearly costs occur.

The following Differential Inflation Rates can be assumed if more accurate information is unavailable.

Differential Inflation Rate of oil or gas is 8%.

Differential Inflation Rate of electricity is 7%.

Differential Inflation Rate of other items discussed is 0%.

Photovoltaic power systems are cost-effective and should be purchased when their life-cycle costs are less than the life-cycle costs of the conventional power sources. The life-cycle cost considerations of the conventional sources are fairly straightforward and easy to compute.

The one-time capital cost of a diesel power source includes diesel generator and fuel storage costs. These costs can be determined from actual acquisition costs of similar systems. The operating and maintenance costs are also determined from actual costs. In many remote applications, the cost of fuel and fuel delivery plus the maintenance costs, which include parts and labor and transportation costs of the maintenance crew, can result in a very high recurring yearly cost. The recurring yearly cost can very easily be higher than the one-time capital cost.

The one-time capital cost of a battery power system can easily be determined from actual battery costs. Replacement battery costs can be assumed to be the same as the initial battery capital cost, and they will occur at the end of the battery power system's useful life. The operating and maintenance costs of a remote battery power system are very high. Personnel must regularly take the batteries to the charging station and return them to the application site, or a second bank of batteries must be purchased so that one bank will always be charged to replace the other bank at the application site. The cost of the electricity in recharging the batteries must be included in the operating cost of the system.

The one-time capital cost of extending an existing utility grid to a remote location can be obtained from the local utility company. The operating and maintenance costs are for occasional inspection of the utility distribution line and the cost of the electricity supplied to the application.

The one-time cost of a photovoltaic power system includes the initial procurement and installation costs. The one-time future cost is the battery replacement cost. The operating and maintenance costs, which are for visual inspection of the photovoltaic array and maintenance of the battery storage, are low and can be determined with reasonable accuracy. The big unknown is the initial procurement and installation costs of a photovoltaic power system.

Whereas the costs of the conventional power systems can be easily determined by the using activity, the costs of a photovoltaic power system are supplied by this report, using Equations 11 and 12 (see examples in Appendix B). Equation 11 is used to calculate the one-time procurement cost.

$$\begin{aligned}
 \text{initial one-time} \\
 \text{procurement cost} \\
 \text{of a photovoltaic} \\
 \text{power system (\$)} &= \text{total peak} \times \text{photovoltaic module} + \text{total peak} \times \text{voltage regulator} \\
 &\quad \text{watts (W)} \times \text{cost per watt (\$/W)} + \text{watts (W)} \times \text{cost per watt (\$/W)} \\
 &\quad + 60 (\$) + \text{total peak} \times \text{arraying} + \text{actual battery} \\
 &\quad \text{watts (W)} \times \text{cost per watt (\$/W)} + \text{storage size (Wh)} \\
 &\quad \times \text{battery cost} + \text{total peak} \times \text{inverter} \\
 &\quad \text{per watt-hour (\$/Wh)} + \text{inverter watts (W)} \times \text{cost per watt (\$/W)} + 690 (\$) \quad (11)
 \end{aligned}$$

where

total peak watts (W) = result of Equation 4.

NWC TP 6381

photovoltaic module cost per watt (\$/W) = cost information obtained from the photovoltaic module specification sheet (Appendix C). The cost must be in \$/W, so it may be necessary to divide the module cost by the module peak watts to obtain the \$/W. If no actual cost information is available, use the curve in Figure 10, which shows the expected cost of photovoltaic modules in \$/W for the next several years.

voltage regulator cost per watt (\$/W) = 0.20 \$/W.

60 (\$) = the minimum amount that a voltage regulator would cost. Do not include the 60 \$ if no voltage regulators are used.

arraying cost per watt (\$/W) = arraying includes photovoltaic support structure, wiring harnesses, and connectors. Arraying cost is estimated at 1.25 \$/W.

actual battery storage size (Wh) = result of Equation 8.

battery cost per watthour (\$/Wh) = 0.16 \$/Wh.

total peak inverter watts (W) = the largest power requirement the inverter must supply in watts. If the photovoltaic power system has more than one inverter, add the peak inverter watts of each together.

inverter cost per watt (\$/W) = 1.16 \$/W.

690 (\$) = the minimum amount that an inverter would cost. Do not include the 690 \$ if no inverter is used.

When these assumptions are used, Equation 11 reads as follows:

$$\begin{aligned}
 \text{initial one-time} \\
 \text{procurement cost} &= \text{total peak} \times \text{photovoltaic module} + \text{total peak} \times 0.20 \text{ ($/W)} \\
 \text{of a photovoltaic} &= \text{watts (W)} \times \text{cost per watt ($/W)} + \text{watts (W)} \times 0.20 \text{ ($/W)} \\
 \text{power system ($)} & \\
 &+ 60 \text{ ($)} + \text{total peak} \times 1.25 \text{ ($/W)} + \text{actual battery} \\
 &\quad \text{watts (W)} \quad \text{storage size (Wh)} \\
 &\times 0.16 \text{ ($/Wh)} + \text{total peak} \times 1.16 \text{ ($/W)} + 690 \text{ ($)} \\
 &\quad \text{inverter watts (W)}
 \end{aligned} \tag{11}$$

Equation 12 is used to calculate the installation cost of a photovoltaic power system.

$$\begin{aligned}
 \text{installation cost of a} &= \text{total peak} \times \text{installation} \\
 \text{photovoltaic power system ($)} &= \text{watts (W)} \times \text{cost per watt ($/W)}
 \end{aligned} \tag{12}$$

where

total peak watts (W) = result of Equation 4.

installation cost per watt (\$/W) = 17.0 \$/W.

NWC TP 6381

The total one-time capital cost of a photovoltaic power system is the sum of the results of Equations 11 and 12.

The future battery replacement cost is computed from Equation 13 (see example in Appendix B).

$$\text{future battery replacement cost (\$)} = \frac{\text{actual battery storage size (Wh)}}{\text{storage size (Wh)}} \times 0.16 (\$/\text{Wh}) \quad (13)$$

where

actual battery storage size (Wh) = result of Equation 8.

0.16 (\$/Wh) = battery cost per watthour.

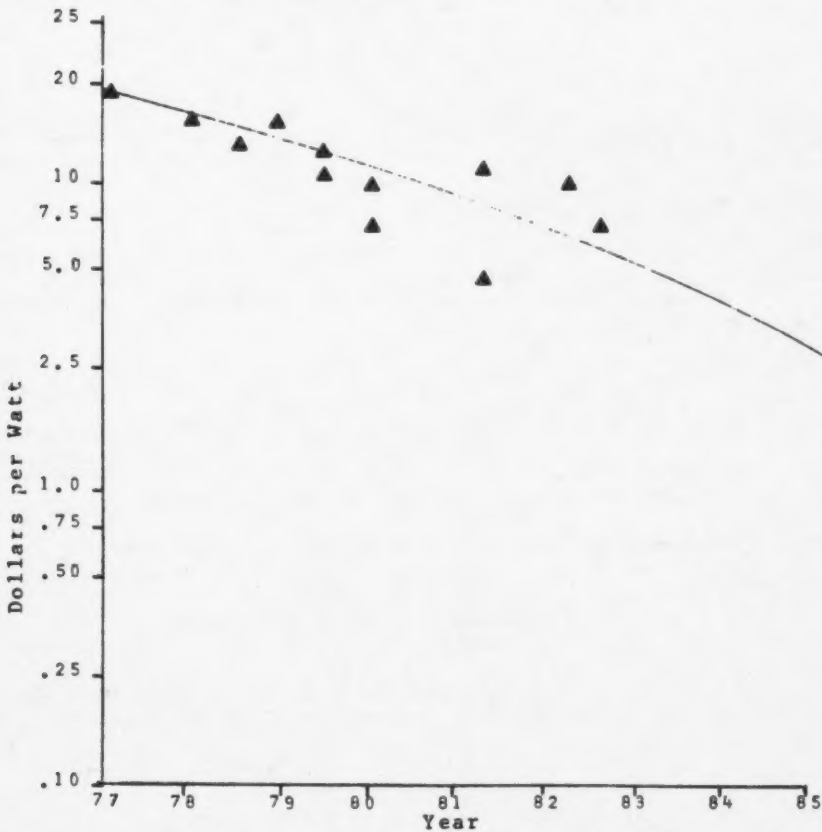


FIGURE 10. Projected Photovoltaic Module Cost.

Equation 14 provides the operating and maintenance costs of a photovoltaic power system (see example in Appendix B).

$$\begin{aligned} \text{operating and maintenance} \\ \text{costs of a photovoltaic} \\ \text{power system (\$/yr)} &= \frac{\text{actual battery}}{\text{storage size (Wh)}} \times 0.001 (\$/\text{Wh}) \\ &+ \frac{\text{personnel}}{\text{transportation}} \times 2 (\text{trips/yr}) \\ &\quad \text{costs per trip (\$/trip)} \end{aligned} \quad (14)$$

where

actual battery storage size (Wh) = result of Equation 8.

0.001 (\$/Wh) = cost of performing battery maintenance per watthour of battery capacity. (Photovoltaic array requires no maintenance.)

personnel transportation costs per trip (\$/trip) = hourly cost of personnel times the number of personnel times round-trip travel time plus vehicle cost, if any.

2 (trips/yr) = two battery maintenance trips each year.

Some Navy funding procedures may require that a photovoltaic power system be cost-effective in fewer years than its economic life. For these systems, perform the life-cycle cost comparisons only for the portions of the cash flow diagrams in Figure 9 that fall within the specified number of years.

In any life-cycle cost analysis that shows the photovoltaic power system as not cost-effective, it is useful to determine when, if ever, the system would become cost-effective. The photovoltaic module cost has the greatest impact on the cost of the photovoltaic power system and is most likely to change with time (Figure 10). The other items are not very time dependent. The photovoltaic module cost that makes the power system cost-effective is known as the economic module cost, which can be determined by the following steps.

Step 1. Calculate the lowest life-cycle cost of the three competing conventional power sources by using Equation 10.

Step 2. Use the lowest life-cycle cost from step 1 and use Equation 10 to calculate the cost-effective initial one-time cost for the photovoltaic power system.

Step 3. Use the answer in step 2 and Equations 11 and 12 to calculate the economic module cost by solving for the photovoltaic module cost per watt in Equation 11 (only unknown term).

If the economic module cost is negative, the photovoltaic power system will never be cost-effective. If the cost is positive, Figure 10 will indicate in what year the photovoltaic power system will be cost-effective.

NWC TP 6381

CONCLUSIONS

Photovoltaic power systems are viable alternatives to conventional power sources for remote applications. These systems are life-cycle cost-effective when the remote-application costs are high for operating and maintaining diesel generators and battery power sources and initially extending an existing utility grid.

Photovoltaic systems will supply reliable, quiet, pollution-free power. They use a renewable natural resource and therefore require no refueling. A radio-controlled switch can be used to turn the system on and off, when desired, making it unnecessary for personnel to man the site. The ability to operate satisfactorily for long unattended periods of time in very remote locations makes photovoltaic systems ideal for remote mountain-top applications such as communication equipment.

Due to the high initial costs of photovoltaic power systems, they are currently cost-effective primarily for small, remote applications. As the photovoltaic module costs decrease, the systems will become cost-effective for larger, remote applications and finally for grid-connected applications. Photovoltaic systems receive their power from solar radiation and are therefore primarily limited for use in sunny locations.

Following is a list of remotely located applications that are representative of the types of loads most likely to be cost-effective for photovoltaic power use. These and similar applications should be investigated for possible conversion to photovoltaic power.

1. Monitoring and sensing devices:
 - remote weather stations/transmitters
 - remote air- and water-pollution monitoring
 - sunrise and sunset indicators
 - seismic detectors/transmitters
 - snow/rain gauges
 - flood monitors
 - oceanographic data platforms
2. Marking and warning devices:
 - obstruction/hazard lights
 - navigation aids/systems
 - VOR
 - VORTAC
 - TACAN
 - rotating beacons
 - sonar buoys and underwater channel markers
 - offshore-platform navigation aids
 - railroad-crossing signals
 - highway-sign defrosters
 - radar-boresight beacons
3. Communication equipment:
 - microwave repeaters
 - field-telephone system

NWC TP 6381

telephone call box
low-frequency communication
radio telephones
pocket paging systems

4. Lighting:
 - signs
 - remote airfields
 - remote sites
5. Remote instrumentation:
 - data links
 - telemetry
 - remote instrumentation sites
 - buildings
 - camera stations
 - radar
 - beacons
 - repeaters
 - closed-circuit remote TV
 - bomb-scoring devices
6. Comfort facilities
7. Security:
 - remotely controlled and monitored gates
 - IR, TV seismic-intrusion devices
 - sentry sites
 - electrified fences
 - TV monitors
8. Battery charging
9. Boating applications
10. Radar for speed control
11. Field mess
12. Power for mini/microcomputers/calculators
13. Battery-charged tools
14. Space heating, cooling, ventilating at specific sites
15. Fire-alarm systems
16. Insect repellents
17. Power for intelligence units

NWC TP 6381

18. Water pumping
19. Water purification/desalination
20. Power pumps to circulate solar hot water
21. Fuel pumping
22. Power source for life rafts (water purification, brewing coffee, sending distress signals, radio reception and transmission)
23. Power for automatic gates and doors
24. Distress/emergency beacons
25. Event recorder
26. Modular power for self-supportive stations (Seabees)
27. Low-energy lasers
28. Cathodic protection:
 - pipelines
 - wellheads and casings
 - highway bridges
 - underground storage

NWC TP 6381

BIBLIOGRAPHY

PRC Energy Analysis Company. *Solar Photovoltaic Applications Seminar: Design, Installation and Operation of Small, Stand-Alone Photovoltaic Power Systems*. Springfield, Va., National Technical Information Service, Dept. of Energy, July 1980. (DOE/CS/32522-T1, publication UNCLASSIFIED.)

Solar Energy Research Institute. *Interim Performance Criteria for Photovoltaic Energy Systems*. Springfield, Va., National Technical Information Service, SERI, December 1980. (SERI/TR-742-654, publication UNCLASSIFIED.)

Appendix A

**EQUATIONS AND WORKSHEETS FOR PHOTOVOLTAIC
POWER SYSTEM SIZING AND COST ANALYSIS**

NWC TP 6381

Equation 1

$$\text{load (Wh/day)} = \frac{\text{duty cycle (Wh/day)}}{\text{power conditioning efficiency (decimal)}}$$

Equation 2

$$\text{number of series photovoltaic modules} = \frac{\text{nominal battery storage voltage (VDC)}}{\text{nominal photovoltaic module voltage (VDC/module)}}$$

Equation 3

$$\text{number of parallel photovoltaic modules} = \frac{\text{load (Wh/day)} \times 1.20}{\text{nominal battery storage voltage (VDC)} \times \text{equivalent peak hours per day (h/day)} \times \text{nominal photovoltaic module current (A/module)}}$$

Equation 4

$$\text{total peak watts (W)} = \text{number of series photovoltaic modules} \times \text{number of parallel photovoltaic modules} \times \text{peak watts per photovoltaic module (W)}$$

Equation 5

$$\text{designed battery storage size (Wh)} = \frac{\text{load (Wh/day)} \times 1.20 \times \text{required days of storage (day)}}{\text{depth of discharge (decimal)}}$$

Equation 6

$$\text{number of series batteries} = \frac{\text{nominal battery storage voltage (VDC)}}{\text{nominal single battery voltage (VDC/battery)}}$$

Equation 7

$$\text{number of parallel batteries} = \frac{\text{designed battery storage size (Wh)}}{\text{nominal battery storage voltage (VDC)} \times \text{nominal ampere hours per battery (Ah/battery)}}$$

NWC TP 6381

Equation 8

$$\text{actual battery storage size (Wh)} = \frac{\text{number of series batteries}}{\text{number of parallel batteries}} \times \frac{\text{nominal ampere hours per battery (Ah)}}{\text{nominal single battery voltage (VDC)}}$$

Equation 9

$$\text{peak battery current requirement (A)} = \frac{\text{peak load power requirement (W)}}{\text{nominal battery storage voltage (VDC)}} \times \frac{\text{number of parallel batteries}}{\text{number of parallel batteries}}$$

Equation 10

$$\begin{aligned} \text{life-cycle cost (present value) (\$)} &= \text{initial one-time cost (\$)} + \text{future one-time cost (\$)} \times \text{single-amount discount factor} \\ &+ \text{equal recurring yearly costs (\$)} \times \text{cumulative-uniform-series discount factor} \end{aligned}$$

Equation 11

$$\begin{aligned} \text{initial one-time procurement cost of a photovoltaic power system (\$)} &= \text{total peak watts (W)} \times \text{photovoltaic module cost per watt (\$/W)} + \text{total peak watts (W)} \times \text{voltage regulator cost per watt (\$/W)} \\ &+ 60 (\$) + \text{total peak watts (W)} \times \text{arraying cost per watt (\$/W)} + \text{actual battery storage size (Wh)} \\ &\times \text{battery cost per watt-hour (\$/Wh)} + \text{total peak inverter watts (W)} \times \text{inverter cost per watt (\$/W)} + 690 (\$) \\ &= \text{total peak watts (W)} \times \text{photovoltaic module cost per watt (\$/W)} + \text{total peak watts (W)} \times 0.20 (\$/W) \\ &+ 60 (\$) + \text{total peak watts (W)} \times 1.25 (\$/W) + \text{actual battery storage size (Wh)} \\ &\times 0.16 (\$/Wh) + \text{total peak inverter watts (W)} \times 1.16 (\$/W) + 690 (\$) \end{aligned}$$

Equation 12

$$\begin{aligned} \text{installation cost of a} & \quad \text{total peak} & \quad \text{installation} \\ \text{photovoltaic power system (\$)} & = \text{watts (W)} \times \text{cost per watt (\$/W)} \\ & = \text{total peak} \\ & \quad \text{watts (W)} \times 17.0 (\$/W) \end{aligned}$$

Equation 13

$$\begin{aligned} \text{future battery} & \quad \text{actual battery} \\ \text{replacement cost (\$)} & = \text{storage size (Wh)} \times 0.16 (\$/Wh) \end{aligned}$$

Equation 14

$$\begin{aligned} \text{operating and maintenance} & \quad \text{actual battery} \\ \text{costs of a photovoltaic} & = \text{storage size (Wh)} \times 0.001 (\$/Wh) \\ \text{power system (\$/yr)} & \\ + \quad \text{personnel} & \\ \quad \text{transportation} & \times 2 \text{ (trips/yr)} \\ \quad \text{costs per trip (\$/trip)} & \end{aligned}$$

NWC TP 6381

Photovoltaic Array Sizing Worksheet

Equation 1. Load (Wh/day) = $\frac{W}{7 \text{ day/week}} \times \frac{h/\text{day}}{\text{efficiency in decimal form}} \times \frac{\text{day/week}}{\text{efficiency in decimal form}}$ = _____ Wh/day

Equation 2. Number of series photovoltaic modules = $\frac{VDC \text{ (nominal storage voltage)}}{VDC \text{ (nominal module voltage)}}$ = _____ modules

Equation 3. Number of parallel photovoltaic modules = _____

	Load (Wh/day)		Nominal battery storage voltage (VDC)	Equivalent peak hours per day (h/day)	Nominal photovoltaic module current (A/module)	Number of parallel photovoltaic modules Calc. Next higher whole number
Jan	X 1.20					
Feb	X 1.20					
Mar	X 1.20					
Apr	X 1.20					
May	X 1.20					
Jun	X 1.20					
Jul	X 1.20					
Aug	X 1.20					
Sep	X 1.20					
Oct	X 1.20					
Nov	X 1.20					
Dec	X 1.20					largest answer

Equation 4. Total peak (W) = $\frac{\text{(answer from Equation 2)}}{\text{(largest answer from Equation 3)}} \times \frac{\text{(largest answer from Equation 3)}}{\text{(largest answer from Equation 3)}} \times \frac{\text{W (peak watts per module)}}{\text{(largest answer from Equation 3)}} = \text{_____ W}$

NWC TP 6381

Battery Storage Sizing worksheet

Equation 5. Designed battery storage size (Wh) =

	Load (Wh/day)		Required days of storage (day)	Depth of Discharge (decimal)	Designed battery storage size (Wh)
Jan		X	1.20	X	
Feb		X	1.20	X	
Mar		X	1.20	X	
Apr		X	1.20	X	
May		X	1.20	X	
Jun		X	1.20	X	
Jul		X	1.20	X	
Aug		X	1.20	X	
Sep		X	1.20	X	
Oct		X	1.20	X	
Nov		X	1.20	X	
Dec		X	1.20	X	
					Largest answer

Equation 6. Number of series batteries = $\frac{\text{VDC (nominal storage voltage)}}{\text{VDC/battery (nominal battery voltage)}}$ = _____ batteries

Equation 7. Number of parallel batteries = $\frac{\text{Wh (largest answer from Equation 5)}}{\text{VDC (nominal storage voltage)} \times \text{Ah/battery (nominal amp-hours per battery)}}$ = _____ batteries

Equation 8. Actual battery (Wh) storage size = $\frac{\text{(answer from Equation 6)} \times \text{(answer from Equation 7)} \times \text{Ah/battery (nominal amp-hours per battery)}}{\text{VDC (nominal battery voltage)}}$ = _____ Wh

Battery storage ability to supply peak current requirement.

Step 1. Solve Equation 9.

Equation 9. Peak battery (A) current requirement = $\frac{\text{W (peak load)}}{\text{VDC (nominal storage voltage)} \times \text{(answer from Equation 7)}}$ = _____ A

Step 2. Number of hours battery storage can supply answer from Equation 9 = _____ hours

Step 3. Number of hours battery storage is required to supply answer from Equation 9 = $\frac{\text{h/day (duty cycle of peak load)} \times \text{day (required days)}}{\text{hours}}$

Step 4. If answer in step 3 is less than answer in step 2, the battery storage design is satisfactory. If answer in step 3 is greater than the answer in step 2, add 1 parallel string of batteries and go back to step 1. When the answer in step 3 is finally less than the answer in step 2, use the new number of parallel strings of batteries and recalculate equation 8.

NWC TP 6381

Cost Worksheet

Equation 10. Life cycle cost (\$) for diesel power source = _____ \$ (diesel generator cost) + _____ \$ (fuel storage cost) + _____ \$ (yearly fuel cost)

X _____ (cumulative uniform series (CUS) discount factors for differential inflation rate (DIR) of 8%) + _____ \$ (yearly maintenance cost)

X _____ (CUS for DIR of 0%) = _____ \$

Equation 10. Life cycle cost (\$) for battery power source = _____ \$ (battery cost) + _____ \$ (first battery replacement cost) X _____ (first single amount (SA) discount factor for DIR of 0%)

+ _____ \$ (second battery replacement cost) X _____ (second SA for DIR of 0%) + _____ \$ (yearly cost of electricity)

X _____ (CUS for DIR of 7%) + _____ \$ (yearly maintenance cost) X _____ (CUS for DIR of 0%) = _____ \$

Equation 10. Life cycle cost (\$) for extending utility grid = _____ \$ (extension cost) + _____ \$ (yearly cost of electricity) X _____ (CUS for DIR of 7%)

+ _____ \$ (yearly maintenance cost) X _____ (CUS for DIR of 0%) = _____ \$

Equation 11. Initial one time (\$) procurement cost of a photovoltaic power system = _____ W (answer from Equation 4) X _____ \$/W (photovoltaic module cost) + _____ W (answer from Equation 4)

X 0.20 \$/W + \$60 + _____ W (answer from Equation 4) X 1.25 \$/W + _____ W (answer from Equation 8)

X 0.16 \$/W + _____ W (peak inverter size) X 1.16 \$/W + \$690 = _____ \$

Equation 12. Installation cost (\$) of a photovoltaic power system = _____ W (answer from Equation 4) X 17.0 \$/W = _____ \$

Equation 13. Future battery replacement cost = _____ W (answer from Equation 8) X 0.16 \$/W = _____ \$

Equation 14. Operating and maintenance (\$/yr) cost of a photovoltaic power system = _____ W (answer from Equation 8) X 0.001 \$/W + _____ \$/trip (personnel cost per trip)

X 2 trip/yr = _____ \$/yr

Equation 10. Life cycle cost (\$) for photovoltaic power system = _____ \$ (answer from Equation 11) + _____ \$ (answer from Equation 12) + _____ \$ (answer from Equation 13)

X _____ (first SA for DIR of 0%) + _____ \$ (answer from Equation 13) X _____ (second SA for DIR of 0%)

+ _____ \$/yr (answer from Equation 14) X _____ (CUS for DIR of 0%) = _____ \$

Economic module (\$/W) cost per watt = _____ \$ (smallest answer for Equation 10) of conventional power sources - _____ \$/yr (answer from Equation 14) X _____ (CUS for DIR of 0%)

- _____ \$ (answer from Equation 13) X _____ (first SA for DIR of 0%) - _____ \$ (answer from Equation 13) X _____ (second SA for DIR of 0%)

- _____ \$ (answer from Equation 12) - \$690 - _____ W (peak inverter watts) X 1.16 \$/W - _____ W (answer from Equation 8)

X 0.16 \$/W - _____ W (answer from Equation 4) X 1.25 \$/W - \$60 - _____ W (answer from Equation 4) X 0.20 \$/W

_____ W (answer from Equation 4)

_____ \$/W

Appendix B

**PHOTOVOLTAIC POWER SYSTEM LOAD IDENTIFICATION,
SYSTEM SIZING, AND COSTING EXAMPLE**

NWC TP 6381

PHOTOVOLTAIC POWER SYSTEM LOAD IDENTIFICATION

1. The enclosed form, "Photovoltaic Power System Requirements," must be accurately completed before a valid assessment can be made as to the feasibility and cost-effectiveness of the proposed application. The following instructions will help to adequately complete the form.

2. **Title:** The title can be any designation that identifies the application.

3. **Location:** Supply name of activity, city, and state. If the application is located remote to the main site area, give a brief description of the location (e.g., mountain-top, desert, valley).

4. **Contact:** Supply name and address of person who will be responsible for the system. This person will be responsible for supplying application requirements and information on operating status. Include the person's business commercial phone number and AUTOVON phone number (if any).

5. **Description of Use:** Supply a brief description of the application. Include the type of equipment to be powered (e.g., electronics, radios, motors) and the present source of power.

6. **Power Requirements:** Supply information on the power requirements of the application. Include voltage requirements (VAC or VDC) and frequency used (e.g., 115 VAC, 60 Hz; 208 VAC, 3-phase, 400 Hz). Supply the application's duty cycles. Include *all* duty cycles. If the application is shut down during part of the year, include that information. For example, if the application is communication equipment, it may have a continuous standby load of 50 watts, a receiving load of 400 watts, and a transmitting load of 800 watts. The application may be in a receiving mode 6 h/day, Monday through Friday, and in a transmitting mode 2 h/day, Monday through Friday. Assuming the application uses 115 VAC, 60 Hz frequency, this example application would be entered as follows:

Power requirements:

System voltage:	_____	VDC	_____	115	VAC	_____	60	Hz
Duty cycle: A	_____	50	watts	_____	24	h/day	_____	7
B	_____	400	watts	_____	6	h/day	_____	5
C	_____	800	watts	_____	2	h/day	_____	5
D	_____	_____	watts	_____	_____	h/day	_____	_____

(Power requirements must be as complete and as accurate as possible. The complete power usage must be known so that the photovoltaic power system can be designed properly.)

NWC TP 6381

It is extremely important that accurate power requirements are supplied. A photovoltaic power system can cost as much as \$1 for every watt-hour used by the application in a week depending on location. If a continuous load requirement is overestimated by as little as 10 watts, that is, $10 \text{ W} \times 24 \text{ h/day} \times 7 \text{ days/wk} \times \$1/\text{Wh/wk}$, it will result in an excess cost of \$1,680. The best way to determine accurate power requirements is to measure the actual power used by the application. Next best is to use the nameplate power requirements of the application. Guesses and diesel nameplate ratings (if diesels are used) are not acceptable sources for the application power requirements.

7. **Site Information:** Site information such as maximum and minimum temperatures, maximum wind velocity, longitude, latitude, and elevation are all necessary for designing the photovoltaic power systems. Extreme accuracy of these parameters is not necessary, and best guesses are acceptable. Remember that these parameters will be used to design the system, and the system cannot be expected to operate outside of these parameters.

Indicate the amount of land or roof area available for the photovoltaic power system. Indicate any obstructions that would keep the sunlight from reaching these areas (e.g., buildings, mountains, trees). Remember that the sun is lower in the winter and is subject to different obstructions than in the summer. Indicate how long these obstructions would shade the photovoltaic power system area (e.g., will block the sunlight for "x" number of hours or for "x" number of degrees from the horizontal). Indicate any special site considerations. Is the site on an east or west facing hill? If so, what is the angle from south of the hill? Does the photovoltaic power system need any special protection from animals or people? Are there any environmental limitations on how the photovoltaic power system can be installed? Are there any limitations on gaining access to the site? These and other special site considerations will help to determine the photovoltaic power system size and cost. A photograph of the site is very helpful, but not essential.

8. Good applications for photovoltaic power systems are those where the power requirements are 20 kilowatts or less and the site is remote from power lines. Photovoltaic power systems are practical when the present power system's operating and maintenance costs are high. The advantages of photovoltaic power systems are that they (1) provide very clean power both electrically and environmentally, (2) have very low operating and maintenance costs, (3) are reliable, and (4) can be turned on and off remotely with the use of a radio-controlled power switch, allowing placement of electrical equipment where access is difficult. The primary disadvantage is the photovoltaic power system's high capital costs. Photovoltaic power systems are practical where their high capital costs are less than the present power systems operating and maintenance costs.

9. Additional information on photovoltaic power systems or how to fill out the form can be obtained by calling Michael Hall on AUTOVON 437-3411, extension 241, or commercial (619) 939-3411, extension 241.

NWC TP 6381

PHOTOVOLTAIC POWER SYSTEM REQUIREMENTS

TITLE: _____

LOCATION: _____

CONTACT: _____

Phone: _____

DESCRIPTION OF USE: _____

POWER REQUIREMENTS: Source of requirements: _____

System voltage: _____ VDC _____ VAC _____ Hz

Duty cycle: A _____ watts _____ h/day _____ day/wk

B _____ watts _____ h/day _____ day/wk

C _____ watts _____ h/day _____ day/wk

D _____ watts _____ h/day _____ day/wk

(Power requirements must be as complete and as accurate as possible. The complete power usage must be known so that the photovoltaic power system can be designed properly.)

SITE INFORMATION: (send picture if possible)

Max. temp. _____ Min. temp. _____ Max. wind _____

Longitude _____ Latitude _____ Elevation _____

Land area available: _____

Roof area available: _____

Shading considerations: _____

Special site considerations: _____

NWC TP 6381

PHOTOVOLTAIC POWER SYSTEM SIZING AND COSTING EXAMPLE

The following assumptions are used to demonstrate the photovoltaic power system sizing technique as outlined in the text of this report.

Application: range instrumentation site
 Application location: Albuquerque, N. Mex.; latitude, 35°0'
 Photovoltaic modules used: Appendix C
 Nominal battery storage voltage: 120 VDC
 Battery storage: lead-acid batteries from Appendix E
 Design storage requirement: 5 days storage required
 Minimum battery storage temperature: -5°F
 Inverter efficiency: 85%

The power requirements (from the example of the Photovoltaic Power System Requirements form) are

duty cycle A = 50 W × 24 h/day = 1200 Wh/day
 duty cycle B = 400 W × 6 h/day × 5 day/wk ÷ 7 day/wk = 1714 Wh/day
 duty cycle C = 800 W × 2 h/day × 5 day/wk ÷ 7 day/wk = 1143 Wh/day

The load power requirement is calculated by using Equation 1.

$$\text{load (Wh/day)} = \frac{\text{duty cycles (Wh/day)}}{\text{power conditioning efficiency (decimal)}} \quad (1)$$

where

duty cycles (Wh/day) = sum of duty cycles.

power conditioning efficiency (decimal) = from example assumptions.

$$\text{load (Wh/day)} = \frac{1200 \text{ Wh/day} + 1714 \text{ Wh/day} + 1143 \text{ Wh/day}}{0.85} = 4773 \text{ Wh/day}$$

The number of series photovoltaic modules needed for this photovoltaic power system is calculated by using Equation 2.

$$\frac{\text{number of series photovoltaic modules}}{\text{photovoltaic modules}} = \frac{\text{nominal battery storage voltage (VDC)}}{\text{nominal photovoltaic module voltage (VDC/module)}} \quad (2)$$

where

nominal battery storage voltage (VDC) = from example assumptions.

NWC TP 6381

nominal photovoltaic module voltage (VDC/module) = specification from Appendix C.

$$\frac{\text{number of series photovoltaic modules}}{\text{photovoltaic modules}} = \frac{120 \text{ VDC}}{12 \text{ VDC}} = 10 \text{ photovoltaic modules}$$

Since the load power requirements are constant throughout the year, the photovoltaic array tilt angle will be selected so that the amount of solar radiation received by the array in the winter is as close as possible to the amount received in the summer. The tables in Appendix D will be used, and a choice of three tilt angles is available in the tables. For a tilt angle of latitude minus 15 degrees, the difference between the winter and summer solar radiation received by the array is 3.4 kWh/m². For a tilt angle of latitude plus 0 degrees, the difference is 1.5 kWh/m²; and for a tilt angle of latitude plus 15 degrees, the difference is 0.0 kWh/m². The tilt angle of latitude plus 15 degrees is selected since it most closely matches the winter and summer solar radiation received by the array. Equation 3 is now solved for each month, and the largest answer is used in the balance of the array sizing (Table B-1). (Remember that the values of equivalent peak hours per day are the same as the values of the daily solar radiation in kWh/m².)

$$\begin{array}{l} \text{number of} \\ \text{parallel} \\ \text{photovoltaic} \\ \text{modules} \end{array} = \frac{\text{load (Wh/day)} \times 1.20}{\begin{array}{l} \text{nominal battery} \\ \text{storage voltage} \\ \text{(VDC)} \end{array} \times \begin{array}{l} \text{equivalent peak} \\ \text{hours per day} \\ \text{(h/day)} \end{array} \times \begin{array}{l} \text{nominal photovoltaic} \\ \text{module current} \\ \text{(A/module)} \end{array}} \quad (3)$$

where

load (Wh/day) = 4773 Wh/day from example Equation 1.

nominal battery storage voltage (VDC) = from example assumptions.

equivalent peak hours per day (h/day) = from Appendix D.

nominal photovoltaic module current (A/module) = specification from Appendix C.

NWC TP 6381

TABLE B-1. Monthly Results of Equation 3.

	Load (Wh/day)			Nominal battery storage voltage (VDC)		Equivalent peak hours per day (h/day)		Nominal photovoltaic module current (A/module)		Number of parallel photovoltaic modules	
										Calc.	Next higher whole number
Jan	4773	X	1.20	÷	120	÷	6.4	÷	1.2	= 6.21	7
Feb	4773	X	1.20	÷	120	÷	6.8	÷	1.2	= 5.85	6
Mar	4773	X	1.20	÷	120	÷	7.1	÷	1.2	= 5.60	6
Apr	4773	X	1.20	÷	120	÷	6.9	÷	1.2	= 5.76	6
May	4773	X	1.20	÷	120	÷	6.4	÷	1.2	= 6.21	7
Jun	4773	X	1.20	÷	120	÷	6.3	÷	1.2	= 6.31	7
Jul	4773	X	1.20	÷	120	÷	6.2	÷	1.2	= 6.42	7
Aug	4773	X	1.20	÷	120	÷	6.7	÷	1.2	= 5.94	6
Sep	4773	X	1.20	÷	120	÷	7.3	÷	1.2	= 5.45	6
Oct	4773	X	1.20	÷	120	÷	7.3	÷	1.2	= 5.45	6
Nov	4773	X	1.20	÷	120	÷	6.7	÷	1.2	= 5.94	6
Dec	4773	X	1.20	÷	120	÷	6.2	÷	1.2	= 6.42	7
											largest answer 7

Equation 4 is used to calculate the total peak watts of photovoltaic modules necessary for the photovoltaic power system.

$$\text{total peak watts (W)} = \frac{\text{number of series photovoltaic modules}}{\text{number of parallel photovoltaic modules}} \times \frac{\text{peak watts per photovoltaic module (W)}}{\text{module (W)}} \quad (4)$$

where

number of series photovoltaic modules = answer from example Equation 2.

number of parallel photovoltaic modules = largest answer from example Equation 3.

peak watts per photovoltaic module (W) = specification from Appendix C.

$$\text{total peak watts (W)} = 10 \times 7 \times 20 \text{ W} = 1400 \text{ W}$$

Battery storage sizing will be illustrated by continuing the example. The designed battery storage size is found by solving Equation 5 for each month and using the largest answer for the balance of the battery storage sizing (Table B-2).

$$\text{designed battery storage size (Wh)} = \frac{\text{load (Wh/day)} \times 1.20 \times \text{required days of storage (day)}}{\text{depth of discharge (decimal)}} \quad (5)$$

NWC TP 6381

where

load (Wh/day) = answer from example Equation 1.

required days of storage (day) = from example assumptions.

depth of discharge (decimal) = from Figure 8.

TABLE B-2. Monthly Results of Equation 5.

	Load (Wh/day)				Required days of storage (day)		Depth of Discharge (decimal)		Designed battery storage size (Wh)
Jan	4773	X	1.20	X	5	÷	0.63	=	45457
Feb	4773	X	1.20	X	5	÷	.56	=	51139
Mar	4773	X	1.20	X	5	÷	.76	=	37682
Apr	4773	X	1.20	X	5	÷	.80	=	35798
May	4773	X	1.20	X	5	÷	.80	=	35798
Jun	4773	X	1.20	X	5	÷	.80	=	35798
Jul	4773	X	1.20	X	5	÷	.80	=	35798
Aug	4773	X	1.20	X	5	÷	.80	=	35798
Sep	4773	X	1.20	X	5	÷	.90	=	35793
Oct	4773	X	1.20	X	5	÷	.80	=	35798
Nov	4773	X	1.20	X	5	÷	.79	=	36251
Dec	4773	X	1.20	X	5	÷	0.68	=	42115
largest answer									51139

The number of series-connected batteries is computed by using Equation 6.

$$\text{number of series batteries} = \frac{\text{nominal battery storage voltage (VDC)}}{\text{nominal single battery voltage (VDC/battery)}} \quad (6)$$

where

nominal battery storage voltage (VDC) = from example assumptions.

nominal single battery voltage (VDC/battery) = specification from Appendix E.

$$\text{number of series batteries} = \frac{120 \text{ VDC}}{6 \text{ VDC/battery}} = 20 \text{ batteries}$$

NWC TP 6381

The number of parallel-connected batteries is computed by using Equation 7.

$$\text{number of parallel batteries} = \frac{\text{designed battery storage size (Wh)}}{\text{nominal battery storage voltage (VDC)} \times \text{nominal ampere hours per battery (Ah/battery)}} \quad (7)$$

where

designed battery storage size (Wh) = largest answer from example Equation 5.

nominal battery storage voltage (VDC) = from example assumptions.

nominal ampere hours per battery (Ah/battery) = specification from Appendix E.

$$\text{number of parallel batteries} = \frac{51,139 \text{ Wh}}{120 \text{ VDC} \times 200 \text{ Ah/battery}} = \frac{2.13 \text{ batteries (rounded to next higher whole number)}}{1} = 3 \text{ batteries}$$

The actual battery storage size is computed by using Equation 8.

$$\text{actual battery storage size (Wh)} = \text{number of series batteries} \times \text{number of parallel batteries} \times \text{nominal ampere hours per battery (Ah)} \times \text{nominal single battery voltage (VDC)} \quad (8)$$

where

number of series batteries = answer from example Equation 6.

number of parallel batteries = answer from example Equation 7.

nominal ampere hours per battery (Ah) = specification from Appendix E.

nominal single battery voltage (VDC) = specification from Appendix E.

$$\text{actual battery storage size (Wh)} = 20 \times 3 \times 200 \text{ Ah} \times 6 \text{ VDC} = \frac{72,000 \text{ Wh (divided by 1000 to convert to kilowatthours)}}{1} = 72 \text{ kWh}$$

The ability of the battery storage to supply the peak battery current requirement of the load is determined as discussed in the text.

Step 1. Solve Equation 9.

$$\text{peak battery current requirement (A)} = \frac{\text{peak load power requirement (W)}}{\text{nominal battery storage voltage (VDC)} \times \text{number of parallel batteries}} \quad (9)$$

NWC TP 6381

where

peak load power requirement (W) = largest duty cycle (from the example of the Photo-voltaic Power System Requirements form assumptions) = $800 \text{ W} \div 0.85 = 941 \text{ W}$.

nominal battery storage voltage (VDC) = from example assumptions.

number of parallel batteries = answer from example Equation 7.

$$\text{peak battery current requirement (A)} = \frac{941 \text{ W}}{120 \text{ VDC} \times 3} = 2.61 \text{ A}$$

Step 2. From the battery design curve in Appendix E, the battery storage can supply 2.61 amperes for about 50 hours at a minimum operating temperature of -5°F .

Step 3. The peak load duty cycle is 2 h/day. The battery storage must supply 2.61 amperes for 2 h/day times 5 days required storage, or 10 hours. The battery storage can meet this requirement and is therefore properly designed.

The economic analysis procedures are illustrated using the example. The following additional information is assumed.

Diesel generators cost 500 \$/kW.

Storage tank costs 200 \$.

Diesel maintenance costs consist of diesel maintenance and fuel delivery requiring 3 men 8 h/day 1 day/month at a cost of 20 \$/h for a total of 5760 \$/yr.

Operating costs are computed as follows: The load uses 4057 Wh/day (from the duty cycles of example Equation 1). The diesel generators use 0.0756 gallon of fuel to produce 1000 Wh of electricity. Diesel fuel costs 0.70 \$/gal. The operating cost is $4057 \text{ Wh/day} \times 365 \text{ day/yr} \times 0.0756 \text{ gal/1000 Wh} \times 0.70 \text{ $/gal}$ which equals 78.36 \$/yr.

Peak load is 800 watts.

Battery power source size is computed from Equation 5 using the worst case (smallest) depth of discharge and a required days of storage equal to 7. From example Equation 5,

$$\text{battery power source size (Wh)} = \frac{4773 \text{ Wh/day} \times 1.20 \times 7 \text{ day}}{0.56} = 71,595 \text{ Wh}$$

Battery power source cost is 0.16 \$/Wh, which equals $71,595 \text{ Wh} \times 0.16 \text{ $/Wh} = 11,455 \text{ $}$.

NWC TP 6381

Battery replacement costs are also 11,455 \$.

Battery maintenance cost requires battery recharging once a week. Recharging requires 2 men, 8 h/day, 1 day/wk, 52 wk/yr, at 25 \$/h, for a total of 20,800 \$/yr.

Battery operating cost is the cost of the electricity to recharge the batteries. Electricity cost is assumed at 0.06 \$/kWh. The load uses 4773 Wh/day from the battery power source (example Equation 1). The battery operating cost is $4773 \text{ Wh/day} \times 365 \text{ day/yr} \div 1000 \text{ Wh/kWh} \times 0.06 \text{ $/kWh} = 104.53 \text{ $/yr}$.

Cost of extending an existing utility grid is 30,000 \$/mi. The application site is 15 miles from the nearest utility grid. The utility grid extension cost equals $30,000 \text{ $/mi} \times 15 \text{ miles} = 450,000 \text{ $}$.

The utility grid maintenance costs are assumed at 1000 \$/yr.

The operating cost equals the energy used times the electricity cost that equals $4057 \text{ Wh/day} \times 365 \text{ day/yr} \div 1000 \text{ Wh/kWh} \times 0.06 \text{ $/kWh} = 88.85 \text{ $/yr}$.

Photovoltaic module cost per watt is assumed at 15 \$/W.

Personnel transportation cost per trip equals $25 \text{ $/h} \times 2 \text{ persons} \times 4 \text{ hours}$, which equals 200 \$/trip.

Once the assumptions have been identified, the life-cycle costs of the three conventional power sources can be calculated from Equation 10, and the life-cycle cost of the photovoltaic power system can be calculated with Equations 10-14.

$$\begin{aligned} \text{life-cycle cost} &= \text{initial one-} + \text{future one-} \times \text{single-amount} \\ \text{(present value) ($) } &= \text{time cost ($) } + \text{time cost ($) } \times \text{discount factor} \\ &+ \text{equal recurring} \times \text{cumulative-uniform-} \\ &\quad \text{yearly costs ($) } \times \text{series discount factor} \end{aligned} \quad (10)$$

The life-cycle cost for the diesel generator power source is calculated by using Equation 10 where

$$\text{initial one-time cost ($) } = \text{diesel generators cost} + \text{fuel storage cost} = 500 \text{ $/kW} \times 800 \text{ W} \div 1000 \text{ W/kW} + 200 \text{ $} = 600 \text{ $}$$

$$\text{future one-time cost ($) } = 0 \text{ $}$$

$$\text{equal recurring yearly costs ($) } = \text{operating and maintenance costs} = 78.36 \text{ $ and } 5760 \text{ $ respectively}$$

$$\text{cumulative-uniform-series discount factor} = \text{that obtained from Appendix F:}$$

$$\text{Differential Inflation Rate of 0\% for 25 years} = 9.524$$

$$\text{Differential Inflation Rate of 8\% for 25 years} = 20.050$$

NWC TP 6381

Equation 10 for diesel generator power source now reads

$$\begin{aligned} \text{life-cycle cost} \\ \text{(present value) (\$)} &= 600 \$ + 78.36 \$ \times 20.050 + 5760 \$ \times 9.524 = 57,029.36 \$ \end{aligned}$$

The life-cycle cost for the battery power source is calculated by using Equation 10

where

$$\text{initial one-time cost (\$)} = 11,455 \$.$$

$$\text{future one-time cost (\$)} = 11,455 \$.$$

single-amount discount factor = that obtained from Appendix F:

$$\text{Differential Inflation Rate of 0\% for year 10} = 0.405.$$

$$\text{Differential Inflation Rate of 0\% for year 20} = 0.156.$$

$$\text{equal recurring yearly costs (\$)} = 20,800 \$ \text{ and } 104.53 \$.$$

cumulative-uniform-series discount factor = that obtained from Appendix F:

$$\text{Differential Inflation Rate of 0\% for 25 years} = 9.524.$$

$$\text{Differential Inflation Rate of 7\% for 25 years} = 18.049.$$

Equation 10 for battery power source now reads

$$\begin{aligned} \text{life-cycle cost} \\ \text{(present value) (\$)} &= 11,455 \$ + 11,455 \$ \times 0.405 + 11,455 \$ \times 0.156 + 20,800 \$ \\ &\quad \times 9.524 + 104.53 \$ \times 18.049 = 217,867.12 \$ \end{aligned}$$

The life-cycle cost for the utility grid extension power source is calculated by using Equation 10

where

$$\text{initial one-time cost (\$)} = 450,000 \$.$$

$$\text{future one-time cost (\$)} = 0 \$.$$

$$\text{equal recurring yearly costs (\$)} = 1000 \$ \text{ and } 88.85 \$.$$

cumulative-uniform-series discount factor = that obtained from Appendix F:

$$\text{Differential Inflation Rate of 0\% for 25 years} = 9.524.$$

$$\text{Differential Inflation Rate of 7\% for 25 years} = 18.049.$$

NWC TP 6381

Equation 10 for utility grid extension power source now reads

$$\text{life-cycle cost (present value) (\$)} = 450,000 \$ + 1000 \$ \times 9.524 + 88.85 \$ \times 18.049 = 461,127.65 \$$$

The life-cycle cost of the photovoltaic power system is calculated by using Equation 10. The values to be used in Equation 10 are calculated by using Equations 11-14.

$$\begin{aligned} \text{initial one-time procurement cost of a photovoltaic power system (\$)} &= \text{total peak watts (W)} \times \text{photovoltaic module cost per watt (\$/W)} + \text{total peak watts (W)} \times 0.20 (\$/W) \\ &+ 60 (\$) + \text{total peak watts (W)} \times 1.25 (\$/W) + \frac{\text{actual battery storage size (Wh)}}{\text{storage size (Wh)}} \\ &\times 0.16 (\$/Wh) + \frac{\text{total peak inverter watts (W)}}{\text{inverter watts (W)}} \times 1.16 (\$/W) + 690 (\$) \end{aligned} \quad (11)$$

where

total peak watts (W) = answer from example Equation 4.

photovoltaic module cost per watt (\$/W) = from cost assumptions.

actual battery storage size (Wh) = answer from example Equation 8.

total peak inverter watts (W) = from cost assumptions.

Equation 11 now reads

$$\begin{aligned} \text{initial one-time procurement cost of a photovoltaic power system (\$)} &= 1400 \text{ W} \times 15 \text{ \$/W} + 1400 \text{ W} \times 0.20 \text{ \$/W} + 60 \$ + 1400 \text{ W} \\ &\times 1.25 \text{ \$/W} + 72,000 \text{ Wh} \times 0.16 \text{ \$/Wh} + 800 \text{ W} \times 1.16 \text{ \$/W} + 690 \$ = 36,228 \$ \\ \text{installation cost of a photovoltaic power system (\$)} &= \frac{\text{total peak watts (W)}}{\text{watts (W)}} \times 17.0 (\$/W) = 1400 \text{ W} \times 17.0 \text{ \$/W} \\ &= 23,800 \$ \end{aligned} \quad (12)$$

NWC TP 6381

The initial one-time cost is the sum of Equations 11 and 12.

$$\text{initial one-time cost (\$)} = 36,228 \$ + 23,800 \$ = 60,028 \$$$

The future one-time cost is the future battery replacement cost and is calculated by using Equation 13.

$$\begin{aligned} \text{future one-time cost (\$)} &= \frac{\text{actual battery}}{\text{storage size (Wh)}} \times 0.16 (\$/\text{Wh}) = 72,000 \text{ Wh} \times 0.16 \$/\text{Wh} \\ &= 11,520 \$ \end{aligned} \quad (13)$$

The single-amount discount factor is obtained from Appendix F for the proper Differential Inflation Rate:

$$\begin{aligned} \text{Differential Inflation Rate of 0\% for year 10} &= 0.405. \\ \text{Differential Inflation Rate of 0\% for year 20} &= 0.156. \end{aligned}$$

The equal recurring yearly costs are the operating and maintenance costs of a photovoltaic power system and are calculated by using Equation 14.

$$\begin{aligned} \text{equal recurring yearly costs (\$)} &= \frac{\text{actual battery}}{\text{storage size (Wh)}} \times 0.001 (\$/\text{Wh}) + \frac{\text{personnel transportation costs per trip (\$/trip)}}{\text{trips/yr}} \\ &\times 2 (\text{trips/yr}) = 72,000 \text{ Wh} \times 0.001 \$/\text{Wh} + 200 \$/\text{trip} \times 2 \text{ trips/yr} \\ &= 472 \$ \end{aligned} \quad (14)$$

The cumulative-uniform-series discount factor is obtained from Appendix F for the proper Differential Inflation Rate:

$$\text{Differential Inflation Rate of 0\% for 25 years} = 9.524.$$

When the answers from Equations 11-14 are substituted into Equation 10, the life-cycle cost for the photovoltaic power system reads as follows:

$$\begin{aligned} \text{life-cycle cost (present value) (\$)} &= 60,028 \$ + 11,520 \$ \times 0.405 + 11,520 \$ \times 0.156 + 472 \$ \\ &\times 9.524 = 70,986.05 \$ \end{aligned}$$

Comparing the life-cycle costs of the four power systems shows that the diesel generator is the most cost-effective with the photovoltaic power system being second most cost-effective. The economic module cost will now be calculated for this example. The lowest life-cycle cost of the three conventional power sources is the 57,029.36 \$ for the diesel generator power source.

This is the life-cycle cost that the photovoltaic power system must have to become cost-effective. When the 57,029.36 \$ is substituted into example Equation 10 for the photovoltaic power system, the cost-effective initial one-time cost can be calculated as follows:

$$57,029.36 \$ = \begin{matrix} \text{initial one-} \\ \text{time cost (\$)} \end{matrix} + 11,520 \$ \times 0.405 + 11,520 \$ \times 0.156 + 472 \$ \\ \times 9.524 = \begin{matrix} \text{initial one-} \\ \text{time cost (\$)} \end{matrix} + 10,958.05 \$$$

Solving for initial one-time cost (\$) gives

$$\text{initial one-time cost (\$)} = 57,029.36 \$ - 10,958.05 \$ = 46,071.31 \$$$

$$\text{initial one-time cost (\$)} = \text{example Equation 11} + \text{example Equation 12}$$

Substituting in the values for the initial one-time cost and example Equation 12 gives

$$46,071.31 \$ = \text{example Equation 11} + 23,800 \$$$

Solving for example Equation 11 gives

$$\text{example Equation 11} = 46,071.31 \$ - 23,800 \$ = 22,271.31 \$$$

$$\text{example Equation 11} = 1400 \text{ W} \times \begin{matrix} \text{photovoltaic module} \\ \text{cost per watt (\$/W)} \end{matrix} + 1400 \text{ W} \times 0.20 \text{ \$/W}$$

$$+ 60 \$ + 1400 \text{ W} \times 1.25 \text{ \$/W} + 72,000 \text{ Wh} \times 0.16 \text{ \$/Wh} + 800 \text{ W}$$

$$\times 1.16 \text{ \$/W} + 690 \$ = 1400 \text{ W} \times \begin{matrix} \text{photovoltaic module} \\ \text{cost per watt (\$/W)} \end{matrix} + 15,228 \$$$

Substituting in the value of example Equation 11 gives

$$22,271.31 \$ = 1400 \text{ W} \times \begin{matrix} \text{photovoltaic module} \\ \text{cost per watt (\$/W)} \end{matrix} + 15,228 \$$$

Solving for the photovoltaic module cost per watt gives the economic module cost.

$$\begin{matrix} \text{photovoltaic module} \\ \text{cost per watt (\$/W)} \end{matrix} = \frac{22,271.31 \$ - 15,228 \$}{1400 \text{ W}}$$

thus

$$\text{economic module cost (\$/W)} = 5.03 \text{ \$/W}$$

NWC TP 6381

Figure 10 shows when the Navy should be able to procure photovoltaic modules through contracts for 5.03 \$/W. The photovoltaic power system in this example should be cost-effective and should be purchased by the Navy in 1985.

Appendix C

**PHOTOVOLTAIC MODULE
SPECIFICATION SHEET**

NWC TP 6381

Specifications

The Module:

Nominal Voltage: 12 VDC
Min. Test Voltage: 16.2 VDC
Test Current: 1.2 Amps
Typical Short Circuit Current: 1.3 Amps
Typical Open Circuit Voltage: 20.0 VDC
Peak Power: 20 Watts
Weight: 7.3 lbs., 3.3 kg.

Note: Power outputs shown are under Standard Test Conditions of 100 mw/cm² and 28°C. temperature.



Appendix D

AVERAGE DAILY
SOLAR INSOLATION TABLES¹

¹ Jet Propulsion Laboratory. *A Handbook of Solar Energy Data for Surfaces of Arbitrary Orientation in the United States and Canada*, by J. H. Smith. Pasadena, Calif., JPL, September 1979. (JPL Document 5101-91, document UNCLASSIFIED.)

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Abilene, TX

Latitude: 32° 20'

Location: Albany, NY

Latitude: 42° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.2	4.7	5.0
F	5.1	5.5	5.6
M	5.9	6.0	5.8
A	6.4	6.2	5.7
M	6.6	6.1	5.4
J	7.2	6.6	5.6
J	6.8	6.3	5.5
A	6.7	6.5	5.9
S	6.1	6.2	6.0
O	5.3	5.7	5.8
N	4.2	4.8	5.1
D	3.8	4.6	4.7

Location: Albuquerque, NM

Latitude: 35° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	5.2	6.0	6.4
F	6.1	6.7	6.8
M	7.2	7.4	7.1
A	7.8	7.6	6.9
M	8.0	7.3	6.4
J	8.2	7.4	6.3
J	7.8	7.2	6.2
A	7.6	7.3	6.7
S	7.3	7.5	7.3
O	6.5	7.1	7.3
N	5.4	6.5	6.7
D	4.8	5.7	6.2

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.2	2.4	2.5
F	2.9	3.1	3.1
M	3.1	3.2	3.0
A	4.6	4.4	4.0
M	5.1	4.7	4.2
J	6.8	6.1	5.3
J	6.1	5.6	4.9
A	5.3	5.1	4.7
S	4.0	4.1	3.9
O	3.9	4.1	4.2
N	4.0	4.6	4.9
D	2.6	3.0	3.2

Location: Amarillo, TX

Latitude: 35° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.7	5.4	5.8
F	5.6	6.1	6.2
M	6.3	6.4	6.2
A	7.1	6.8	6.2
M	7.1	6.5	5.7
J	7.4	6.7	5.7
J	7.2	6.6	5.8
A	7.1	6.9	6.3
S	6.5	6.6	6.4
O	5.7	6.2	6.4
N	4.9	5.6	6.0
D	4.3	5.0	5.5

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Ames, IA

Latitude: 42° 0'

Location: Amherst, MA

Latitude: 42° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.3	4.6	4.7
M	4.8	4.8	4.7
A	5.1	4.9	4.5
M	5.6	5.1	4.5
J	6.1	5.5	4.8
J	6.1	5.6	4.9
A	5.6	5.3	4.9
S	4.9	4.9	4.7
O	4.2	4.5	4.5
N	3.3	3.7	3.9
D	2.7	3.0	3.2

Location: Annapolis, MD

Latitude: 38° 60'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.3	3.4
F	3.8	4.0	4.1
M	4.7	4.8	4.6
A	5.3	5.1	4.7
M	5.7	5.3	4.6
J	6.2	5.6	4.9
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	4.9	5.0	4.8
O	4.2	4.5	4.5
N	2.9	3.3	3.4
D	2.6	3.0	3.1

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.0	2.2	2.3
F	2.9	3.0	3.0
M	4.4	4.4	4.2
A	4.4	4.2	3.8
M	5.0	4.6	4.1
J	5.8	5.2	4.5
J	5.9	5.4	4.7
A	5.2	5.0	4.6
S	4.3	4.4	4.2
O	3.7	4.0	4.0
N	2.6	2.9	3.0
D	2.2	2.5	2.7

Location: Annette, AK

Latitude: 55° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.9	2.2	2.3
F	2.7	2.8	2.8
M	4.3	4.4	4.2
A	5.2	5.0	4.5
M	5.3	4.8	4.2
J	5.0	4.5	3.9
J	5.0	4.6	4.0
A	4.3	4.1	3.7
S	3.9	3.9	3.8
O	2.2	2.3	2.3
N	1.4	1.5	1.6
D	1.2	1.4	1.5

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Apalachicola, FL

Latitude: 29° 40'

Location: Asheville, NC

Latitude: 35° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.2	4.7	5.0
F	5.1	5.5	5.6
M	5.8	5.9	5.7
A	7.7	6.4	5.9
M	7.9	6.5	5.6
J	5.7	6.1	5.2
J	6.2	5.7	5.0
A	5.9	5.7	5.2
S	5.5	5.7	5.5
O	5.4	5.9	6.0
N	4.6	5.2	5.5
D	3.7	4.3	4.6

Location: Astoria, OR

Latitude: 46° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.8	1.9	2.0
F	2.7	2.9	2.9
M	4.1	4.1	3.9
A	4.9	4.7	4.2
M	5.8	5.3	4.6
J	5.4	4.9	4.3
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	5.0	5.0	4.8
O	3.4	3.6	3.6
N	2.0	2.2	2.3
D	1.5	1.6	1.7

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.5	3.9	4.1
F	4.5	4.8	4.8
M	5.2	5.3	5.1
A	6.1	5.9	5.4
M	6.4	5.9	5.2
J	6.4	5.8	5.0
J	6.3	5.8	5.1
A	6.0	5.8	5.3
S	5.5	5.6	5.4
O	5.0	5.4	5.5
N	3.8	4.3	4.5
D	3.2	3.7	3.9

Location: Atlanta, GA

Latitude: 33° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.5	3.9	4.1
F	4.1	4.4	4.5
M	5.1	5.1	5.0
A	5.9	5.7	5.2
M	6.1	5.6	5.0
J	6.2	5.6	4.9
J	6.1	5.6	5.0
A	5.8	5.6	5.2
S	5.1	5.2	5.0
O	4.7	5.1	5.2
N	3.8	4.3	4.6
D	3.0	3.5	3.7

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Atlantic City, NJ

Latitude: 39° 30'

Location: Baltimore, MD

Latitude: 39° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.4	3.6
F	4.0	4.3	4.4
M	5.6	5.7	5.5
A	5.4	5.2	4.7
M	5.7	5.2	4.6
J	6.4	5.8	5.7
J	6.4	5.7	5.2
A	5.7	5.5	5.0
S	5.1	5.2	5.0
O	4.4	4.8	4.9
N	3.5	3.9	4.1
D	2.7	3.1	3.3

Location: Bethel, AK

Latitude: 60° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.9	2.1	2.2
F	3.7	4.0	4.1
M	6.6	6.8	6.6
A	7.2	6.9	6.3
M	5.7	5.2	4.5
J	5.1	4.6	3.9
J	4.2	3.8	3.3
A	3.2	3.0	2.7
S	3.1	3.2	3.0
O	2.7	3.0	3.0
N	1.6	1.8	1.9
D	1.3	1.5	1.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.4	3.5
F	3.9	4.1	4.2
M	4.8	4.9	4.7
A	5.3	5.1	4.6
M	5.7	5.2	4.6
J	6.2	5.6	4.9
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	4.9	5.0	4.8
O	4.3	4.6	4.6
N	3.0	3.3	3.5
D	2.7	3.0	3.2

Location: Big Spring, TX

Latitude: 32° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.1	4.6	4.9
F	5.0	5.3	5.4
M	6.2	6.4	6.2
A	7.2	6.9	6.3
M	6.5	6.0	5.3
J	6.7	6.1	5.2
J	6.2	5.7	5.0
A	5.4	5.2	4.8
S	6.5	6.7	6.4
O	5.2	5.6	5.7
N	4.2	4.7	5.0
D	4.0	4.6	4.9

NWC TP 6381

INSULATION

(kWh/m²)

Location: Billings, MT

Latitude: 45° 30'

Location: Binghamton, NY

Latitude: 42° 10'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.9	4.1
F	3.5	4.8	4.9
M	5.6	5.8	5.6
A	6.0	5.8	5.2
M	6.3	5.8	5.1
J	6.9	6.2	5.4
J	7.4	6.8	5.9
A	7.0	6.7	6.1
S	6.0	6.2	6.0
O	4.1	4.2	4.5
N	3.4	3.8	4.1
D	2.8	3.3	3.5

Location: Birmingham, AL

Latitude: 33° 30'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.4	3.6
F	4.1	4.3	4.4
M	4.9	4.9	4.8
A	6.0	5.8	5.3
M	6.4	5.9	5.2
J	6.3	5.7	4.9
J	6.2	5.7	5.0
A	5.9	5.7	5.2
S	5.3	5.4	5.2
O	4.8	3.2	5.3
N	3.5	3.9	4.2
D	2.9	3.3	3.5

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.5	2.8	2.9
F	3.4	3.6	3.6
M	4.4	4.4	4.2
A	4.8	4.6	4.2
M	5.7	5.2	4.6
J	6.2	5.6	4.9
J	6.2	5.7	5.0
A	5.7	5.4	5.0
S	4.8	4.9	4.7
O	3.9	4.2	4.2
N	2.3	2.6	2.7
D	2.0	2.3	2.4

Location: Bismarck, ND

Latitude: 46° 30'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.6	4.1	4.3
F	4.9	5.3	5.4
M	5.6	5.7	5.6
A	6.0	5.7	5.2
M	6.6	6.0	5.3
J	6.6	5.9	5.1
J	7.0	6.4	5.6
A	6.4	6.1	5.6
S	5.4	5.5	5.3
O	4.6	5.0	5.1
N	3.2	3.6	3.8
D	2.8	3.2	3.5

NWC TP 6381

INSOLATION
(kWh/m²)

Location: Blue Hill, MA

Latitude: 42° 10'

Location: Boise, ID

Latitude: 43° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	3.6	3.8	3.8
M	4.5	4.5	4.3
A	4.8	4.6	4.2
M	5.4	5.0	4.4
J	5.8	5.2	4.5
J	5.7	5.2	4.6
A	5.2	5.0	4.6
S	4.6	4.7	4.5
O	3.7	4.0	4.0
N	2.6	2.9	3.1
D	2.4	2.7	2.9

Location: Boston, MA

Latitude: 42° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.5	2.8	2.9
F	3.2	3.4	3.4
M	4.3	4.3	4.1
A	4.6	4.4	4.0
M	5.4	5.0	4.4
J	5.5	5.0	4.4
J	5.7	5.2	4.6
A	5.1	4.9	4.5
S	4.4	4.5	4.3
O	3.5	3.8	3.8
N	2.4	2.7	2.8
D	2.2	2.4	2.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	3.1	3.2
F	4.1	4.4	4.4
M	5.1	5.1	5.0
A	6.4	6.1	5.6
M	6.9	6.4	5.5
J	7.2	6.5	5.6
J	7.7	7.1	6.1
A	7.0	6.7	6.1
S	6.3	6.5	6.2
O	5.1	5.5	5.6
N	3.3	3.7	3.9
D	2.3	2.6	2.8

Location: Boulder, CO

Latitude: 40° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.7	4.2	4.4
F	4.4	4.7	4.8
M	5.9	6.0	5.8
A	5.8	5.6	5.1
M	5.3	4.9	4.3
J	5.9	5.3	4.6
J	5.9	5.4	4.8
A	5.2	5.0	4.6
S	5.4	5.5	5.3
O	4.6	5.0	5.1
N	3.8	4.3	4.5
D	3.4	3.9	4.2

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Brownsville, TX

Latitude: 25° 50'

Location: Cape Hatteras, NC

Latitude: 35° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.8	4.3	4.5
F	4.4	4.7	4.7
M	5.0	5.1	4.9
A	5.5	5.3	4.9
M	6.4	5.9	5.2
J	6.8	6.2	5.4
J	7.0	6.5	5.7
A	6.4	6.2	5.7
S	5.6	5.7	5.5
O	5.1	5.5	5.6
N	3.6	4.0	4.2
D	3.3	3.7	3.9

Location: Caribou, ME

Latitude: 46° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.4	3.6
F	4.4	4.8	4.8
M	6.0	6.1	5.9
A	5.3	5.1	4.6
M	5.5	5.1	4.5
J	5.4	4.9	4.3
J	5.8	5.3	4.6
A	5.5	5.3	4.8
S	4.6	4.7	4.5
O	3.4	3.6	3.6
N	1.9	2.1	2.2
D	2.3	2.6	2.8

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.0	4.5	4.8
F	4.8	5.2	5.3
M	6.0	6.1	5.9
A	7.1	6.8	6.2
M	7.3	6.7	5.9
J	7.3	6.6	5.6
J	7.1	6.5	5.7
A	6.6	6.3	5.8
S	6.0	6.2	5.9
O	5.1	5.5	5.6
N	4.4	5.0	5.3
D	3.4	3.9	4.2

Location: Charleston, SC

Latitude: 32° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.8	4.3	4.5
F	4.4	4.7	4.7
M	5.2	5.3	5.1
A	6.3	6.1	5.6
M	6.3	5.8	5.1
J	6.3	5.7	4.9
J	5.9	5.4	4.8
A	5.8	5.6	5.2
S	5.0	5.1	4.9
O	4.6	4.9	5.0
N	4.1	4.7	4.9
D	3.2	3.7	3.9

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Charlotte, NC

Latitude: 35° 10'

Location: Chattanooga, TN

Latitude: 35° 0'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.6	4.0	4.2
F	4.3	4.8	4.9
M	5.2	5.3	5.1
A	6.3	6.1	5.6
M	6.3	5.8	5.1
J	6.5	5.9	5.1
J	6.4	5.9	5.2
A	6.2	5.9	5.4
S	5.5	5.6	5.4
O	5.0	5.4	5.5
N	3.8	4.3	4.5
D	3.2	3.7	3.9

Location: Chicago, IL

Latitude: 41° 50'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.2	3.6	3.8
F	3.8	4.1	4.1
M	4.8	4.8	4.7
A	4.9	4.7	4.3
M	5.8	5.3	4.7
J	6.2	5.6	4.9
J	6.0	5.5	4.9
A	5.9	5.7	5.2
S	5.1	5.1	4.9
O	4.0	4.3	4.3
N	2.6	2.9	3.0
D	2.3	2.6	2.8

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.4	3.5
F	4.0	4.3	4.3
M	4.6	4.7	4.5
A	5.8	5.5	5.1
M	6.2	5.7	5.0
J	6.3	5.7	4.9
J	6.2	5.7	5.0
A	5.9	5.7	5.2
S	5.4	5.5	5.3
O	4.6	5.0	5.0
N	3.3	3.7	3.9
D	2.8	3.1	3.3

Location: Cleveland, OH

Latitude: 41° 20'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.1	2.3	2.4
F	2.8	3.0	3.0
M	4.5	4.5	4.4
A	4.7	4.5	4.1
M	6.1	5.6	4.9
J	6.3	5.7	4.9
J	6.2	5.7	5.0
A	5.9	5.7	5.2
S	5.0	5.0	4.8
O	3.9	4.2	4.2
N	2.2	2.5	2.6
D	1.9	2.2	2.3

NWC TP 6381

INSOLATION
(kWh/m²)

Location: Columbia, MO

Latitude: 38° 50'

Location: Columbus, OH

Latitude: 40° 0'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.4	3.5
F	3.9	4.1	4.2
M	4.8	4.9	4.7
A	5.4	5.2	4.8
M	6.1	5.7	5.0
J	6.4	5.8	5.0
J	6.5	6.0	5.3
A	6.2	6.0	5.5
S	5.9	6.0	5.8
O	4.7	5.1	5.2
N	3.5	4.0	4.2
D	2.9	3.3	3.5

Location: Corpus Christi, TX

Latitude: 27° 50'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.6	4.0	4.2
F	4.4	4.7	4.8
M	5.3	5.4	5.2
A	5.7	5.5	5.1
M	6.4	5.9	5.2
J	6.9	6.2	5.4
J	7.1	6.6	5.8
A	6.5	6.3	5.8
S	5.6	5.7	5.5
O	3.2	3.6	3.7
N	2.7	4.2	4.4
D	2.2	3.6	3.8

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.2	2.4	2.4
F	3.1	3.3	3.3
M	4.2	4.3	4.1
A	5.0	4.8	4.3
M	5.7	5.2	4.6
J	6.3	5.7	4.9
J	6.1	5.6	4.9
A	5.7	5.5	5.0
S	5.5	5.6	5.4
O	4.3	4.6	4.6
N	2.9	3.2	3.4
D	2.3	2.6	2.7

Location: Corvallis, OR

Latitude: 44° 30'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.8	2.0	2.1
F	2.3	2.4	2.3
M	4.2	4.2	4.1
A	5.2	5.0	4.6
M	6.0	5.5	4.8
J	6.5	5.9	5.1
J	7.7	7.1	6.1
A	6.8	6.5	5.9
S	5.5	5.6	5.4
O	3.4	3.9	3.9
N	2.5	2.7	2.9
D	1.4	1.5	1.6

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Dallas, TX

Latitude: 32° 50'

Location: Davis, CA

Latitude: 38° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.5	4.8	4.8
M	5.2	5.3	5.1
A	5.6	5.4	4.9
M	6.0	5.5	4.9
J	6.7	6.1	5.3
J	6.6	6.1	5.4
A	6.3	6.1	5.5
S	5.7	5.8	5.6
O	4.9	5.2	5.3
N	3.7	4.2	4.4
D	3.3	3.8	4.0

Location: Dayton, OH

Latitude: 39° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.8	3.1	3.2
F	3.6	3.8	3.8
M	4.7	4.8	4.6
A	5.3	5.1	4.6
M	6.0	5.5	4.9
J	6.4	5.8	5.0
J	6.4	5.9	5.2
A	6.1	5.9	5.4
S	5.5	5.6	5.4
O	4.5	4.9	5.0
N	3.0	3.3	3.5
D	2.5	2.8	3.0

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.6	2.9	3.0
F	4.0	4.2	4.3
M	5.7	5.8	5.6
A	6.7	6.5	5.9
M	7.3	6.7	5.9
J	7.8	7.1	6.0
J	7.9	7.2	6.3
A	7.3	7.1	6.5
S	6.6	6.8	6.6
O	5.1	5.6	5.7
N	3.4	3.8	4.0
D	2.4	2.7	2.9

Location: Denver, CO

Latitude: 39° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.8	5.5	5.9
F	5.8	6.3	6.4
M	6.4	6.6	6.4
A	6.6	6.4	5.8
M	6.8	6.3	5.5
J	7.3	6.6	5.7
J	7.2	6.6	5.8
A	7.1	6.9	6.3
S	6.6	6.8	6.5
O	5.7	6.2	6.3
N	4.5	5.2	5.5
D	4.1	4.8	5.2

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Des Moines, IA

Latitude: 41° 30'

Location: Detroit, MI

Latitude: 42° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.4	3.6
F	4.0	4.2	4.3
M	4.7	4.7	4.6
A	3.4	5.2	4.7
M	6.0	5.5	4.9
J	6.3	5.7	4.9
J	6.4	5.9	5.2
A	6.0	5.8	5.3
S	5.4	5.5	5.3
O	4.5	4.9	5.0
N	3.2	3.6	3.8
D	2.5	2.8	3.0

Location: Dodge City, KA

Latitude: 37° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	5.5	5.2	5.5
F	5.2	5.7	5.8
M	6.1	6.3	6.1
A	6.8	6.6	6.0
M	6.6	6.1	5.3
J	7.4	6.7	5.7
J	7.3	6.7	5.9
A	7.0	6.8	6.2
S	6.4	6.6	6.4
O	5.6	6.0	6.2
N	4.6	5.3	5.6
D	4.1	4.8	5.2

TILT ANGLE

MONTH	LATITUDE -1°	LATITUDE	LATITUDE +15°
J	2.4	2.6	2.7
F	3.3	3.5	3.5
M	4.4	4.4	4.2
A	4.9	4.7	4.3
M	5.8	5.3	4.7
J	6.2	5.6	4.9
J	6.3	5.8	5.1
A	5.9	5.6	5.1
S	5.2	5.2	5.0
O	4.2	4.5	4.5
N	2.4	2.7	2.8
D	2.0	2.3	2.4

Location: Duluth, MN

Latitude: 46° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	3.9	4.2	4.3
M	5.1	5.2	5.0
A	5.3	5.1	4.6
M	5.7	5.2	4.6
J	6.2	5.6	4.9
J	6.3	5.8	5.1
A	5.7	5.5	5.0
S	4.6	4.7	4.5
O	3.8	4.1	4.1
N	2.3	2.6	2.7
D	2.2	2.5	2.7

NWC TP 6381

INSOLATION
(kWh/m²)

Location: East Lansing, MI

Latitude: 42° 45'

Location: El Paso, TX

Latitude: 31° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.0	2.2	2.2
F	3.3	3.5	3.5
M	4.3	4.3	4.1
A	4.3	4.1	3.7
M	5.4	5.0	4.4
J	5.8	5.2	4.5
J	5.8	5.3	4.7
A	5.3	5.1	4.7
S	4.4	4.7	4.5
O	3.6	3.8	3.9
N	2.0	2.2	2.3
D	1.7	1.9	2.0

Location: Ely, NV

Latitude: 39° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.4	5.0	5.4
F	5.6	6.1	6.2
M	6.8	6.9	6.7
A	7.2	6.9	6.3
M	7.2	6.6	5.8
J	8.0	7.2	6.1
J	7.3	6.7	5.9
A	7.3	7.1	6.4
S	6.9	7.1	6.9
O	6.0	6.6	6.7
N	5.1	5.9	6.3
D	4.1	4.8	5.2

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	5.1	5.9	6.3
F	6.3	6.9	7.1
M	7.4	7.6	7.4
A	8.1	7.8	7.1
M	8.2	7.5	6.5
J	8.2	7.4	6.3
J	7.6	7.0	6.1
A	7.5	7.2	6.6
S	7.2	7.4	7.2
O	6.3	6.9	7.1
N	5.3	6.2	6.6
D	4.8	5.7	6.2

Location: Fairbanks, AK

Latitude: 64° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.0	2.3	2.4
F	3.2	3.5	3.6
M	6.2	5.4	6.2
A	6.5	6.3	5.7
M	6.1	5.6	4.8
J	6.1	5.5	4.7
J	5.3	4.8	4.1
A	5.0	4.8	4.3
S	3.2	3.3	3.1
O	2.4	2.5	2.6
N	1.5	1.7	1.8
D	0.7	0.8	0.9

INSOLATION

(kWh/m²)

Location: Fargo, ND

Latitude: 46° 30'

Location: Fort Smith, AR

Latitude: 35° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	3.1	3.2
F	4.0	4.3	4.4
M	4.9	5.0	4.8
A	5.5	5.3	4.3
M	6.0	5.5	4.8
J	5.9	5.3	4.6
J	6.3	5.8	5.1
A	5.8	5.6	5.1
S	4.8	4.9	4.7
O	4.0	4.3	4.3
N	2.4	2.7	2.8
D	2.6	3.0	3.2

Location: Fort Wayne, IN

Latitude: 41° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	3.0	3.2
F	3.5	3.8	3.8
M	4.6	4.6	4.3
A	5.2	4.9	4.3
M	6.1	5.6	4.9
J	6.3	5.9	5.1
J	6.4	5.9	5.2
A	6.1	5.9	5.4
S	5.2	5.3	5.1
O	4.3	4.8	4.9
N	2.8	3.1	3.2
D	2.4	2.7	2.9

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.4	3.6
F	4.0	4.3	4.3
M	4.9	5.0	4.8
A	5.5	5.3	4.9
M	6.1	5.6	5.0
J	6.3	5.7	4.9
J	6.2	5.7	5.0
A	6.2	5.9	5.4
S	5.5	5.6	5.4
O	4.7	5.0	5.1
N	3.5	3.9	4.1
D	2.9	3.3	3.5

Location: Fort Worth, TX

Latitude: 32° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.8	4.3	4.3
F	4.6	5.0	5.0
M	5.7	5.8	5.6
A	5.5	5.4	5.1
M	6.4	5.9	5.2
J	7.2	6.6	5.6
J	6.9	6.4	5.6
A	6.9	6.7	6.1
S	6.3	6.4	6.2
O	5.3	5.8	5.9
N	4.3	4.9	5.2
D	3.7	4.2	4.6

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Fresno, CA

Latitude: 36° 50'

Location: Gainesville, FL

Latitude: 29° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.3	3.4
F	4.5	4.8	4.9
M	6.2	6.3	6.1
A	6.8	6.6	6.0
M	7.3	6.7	5.9
J	7.8	7.1	6.0
J	7.5	6.9	6.0
A	7.2	7.0	6.4
S	6.5	6.7	6.5
O	5.4	5.9	6.0
N	3.7	4.2	4.4
D	2.5	2.8	3.0

Location: Glasgow, NY

Latitude: 48° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.9	4.5	4.8
F	5.4	5.8	5.9
M	6.4	6.5	6.3
A	6.2	5.9	5.4
M	6.7	6.1	5.3
J	6.9	6.2	5.3
J	7.4	6.7	5.9
A	6.7	6.5	5.9
S	6.0	6.1	5.9
O	4.8	5.2	5.3
N	3.3	3.8	4.0
D	2.9	3.4	3.7

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.9	4.4	4.7
F	5.1	5.5	5.6
M	5.8	5.9	5.7
A	6.5	6.3	5.8
M	6.7	6.2	5.5
J	6.1	5.6	4.9
J	5.9	5.4	4.8
A	5.9	5.7	5.2
S	5.4	5.5	5.3
O	4.8	5.1	5.2
N	4.3	4.9	5.2
D	3.6	4.1	4.4

Location: Grand Junction, CO

Latitude: 39° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.2	4.8	5.1
F	5.4	5.9	6.0
M	6.2	6.4	6.2
A	6.8	6.6	6.0
M	7.0	6.4	5.6
J	7.9	7.2	6.1
J	7.6	7.0	6.1
A	7.0	6.7	6.2
S	6.7	6.9	6.7
O	5.7	6.2	6.6
N	4.9	5.1	5.5
D	4.0	4.7	5.1

NWC TP 6381

INSOLATION
(kWh/m²)

Location: Grand Lake, CO

Latitude: 40° 20'

Location: Great Falls, MT

Latitude: 47° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.9	4.5	4.7
F	5.6	5.8	5.9
M	6.2	6.3	6.1
A	6.4	6.4	5.8
M	6.4	5.9	5.2
J	7.1	6.4	5.5
J	6.8	6.2	5.4
A	6.0	5.8	5.3
S	6.4	6.5	6.3
O	5.5	6.1	6.2
N	4.1	4.6	4.9
D	3.4	4.0	4.3

Location: Green Bay, WI

Latitude: 44° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	3.0	3.2
F	3.7	3.9	3.9
M	4.7	4.8	4.6
A	5.0	4.8	4.4
M	5.8	5.3	4.7
J	6.1	5.5	4.8
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	4.8	4.9	4.7
O	3.7	4.0	4.0
N	2.4	2.7	2.8
D	2.1	2.4	2.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.6	3.8
F	4.5	4.8	4.9
M	5.9	6.1	5.9
A	5.7	5.5	5.0
M	6.2	5.7	5.0
J	6.7	6.0	5.2
J	7.4	6.8	5.9
A	6.6	6.4	5.8
S	5.8	5.9	5.7
O	4.5	4.9	5.0
N	3.1	3.5	3.7
D	2.5	2.9	3.1

Location: Greensboro, NC

Latitude: 36° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.3	3.7	3.9
F	4.1	4.3	4.4
M	4.8	4.9	4.7
A	5.9	5.6	5.2
M	6.1	5.6	4.9
J	6.3	5.7	4.9
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	5.2	5.3	5.1
O	4.6	4.9	5.0
N	3.8	4.2	4.5
D	3.0	3.4	3.6

NWC TP 6381

INSOLATION

(kWh/m²)Location: Greenville-
Spartanburg, NC

Latitude: 34° 50'

Location: Griffin, GA

Latitude: 33° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.5	3.9	4.1
F	3.9	4.2	4.2
M	3.2	3.3	3.2
A	6.3	6.1	5.6
M	6.3	5.8	5.1
J	6.3	5.7	4.9
J	6.3	5.8	5.1
A	6.0	5.8	5.3
S	5.3	5.4	5.2
O	5.0	5.4	5.5
N	3.8	4.3	4.5
D	3.2	3.7	3.9

Location: Hartford, CT

Latitude: 41° 60'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	3.8	4.0	4.0
M	4.8	4.8	4.7
A	4.9	4.7	4.3
M	5.6	5.1	4.5
J	6.0	5.4	4.7
J	6.0	5.5	4.9
A	5.6	5.3	4.9
S	4.7	4.8	4.6
O	3.9	4.2	4.2
N	2.7	3.0	3.2
D	3.7	4.3	4.7

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.6	4.1	4.3
F	4.4	4.7	4.7
M	5.2	5.3	5.1
A	6.3	6.1	5.6
M	6.6	6.1	5.4
J	6.5	5.9	5.1
J	6.3	5.8	5.1
A	6.2	5.9	5.4
S	5.4	5.5	5.3
O	5.0	5.4	5.5
N	4.2	4.8	5.0
D	3.1	3.6	3.8

Location: Nilo, HI

Latitude: 19° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	3.9
F	4.5	4.8	4.9
M	5.4	5.5	5.3
A	5.1	4.9	4.5
M	5.1	4.8	4.3
J	6.5	6.0	5.2
J	6.2	5.8	5.1
A	5.7	5.5	5.0
S	5.2	5.3	5.2
O	4.0	4.3	4.3
N	3.6	3.9	4.1
D	3.2	3.6	3.8

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Honolulu, HI

Latitude: 21° 20'

Location: Houston, TX

Latitude: 29° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.6	5.2	5.5
F	5.3	5.7	5.8
M	6.3	6.4	6.2
A	6.5	6.3	5.8
M	7.1	6.6	5.7
J	7.0	6.4	5.5
J	7.1	6.5	5.7
A	7.1	6.9	6.3
S	6.7	6.9	6.7
O	6.1	6.6	6.8
N	5.2	6.0	6.4
D	4.7	5.5	5.9

Location: Indianapolis, IN

Latitude: 39° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.5	2.7	2.8
F	3.3	3.5	3.5
M	4.4	4.5	4.3
A	5.0	4.8	4.4
M	5.7	5.2	4.6
J	6.1	5.5	4.8
J	6.1	5.6	4.9
A	5.8	5.6	5.1
S	5.3	5.4	5.2
O	4.3	4.6	4.6
N	2.7	3.1	3.2
D	2.1	2.4	2.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.7	3.9
F	4.2	4.4	4.5
M	5.0	5.1	4.9
A	5.5	5.3	4.9
M	6.3	5.8	5.1
J	6.8	6.2	5.3
J	6.6	6.1	5.4
A	6.1	5.9	5.4
S	5.6	5.7	5.5
O	5.1	5.5	5.6
N	3.7	4.2	4.4
D	3.2	3.6	3.9

Location: Inyokern, CA

Latitude: 35° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	5.3	6.2	6.6
F	6.7	7.3	7.5
M	8.2	8.6	8.2
A	8.8	8.5	7.8
M	9.1	8.3	7.2
J	9.3	8.4	7.1
J	8.8	8.1	7.0
A	8.9	8.6	7.8
S	8.4	8.7	8.4
O	7.0	7.7	8.0
N	5.9	6.8	7.3
D	5.1	6.1	6.6

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Ithaca, NY

Latitude: 42° 30'

Location: Jackson, MS

Latitude: 33° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.1	2.3	2.4
F	3.4	3.6	3.6
M	4.1	4.1	3.9
A	4.4	4.2	3.8
M	5.4	5.0	4.4
J	6.0	5.4	4.7
J	6.1	5.6	4.9
A	5.5	5.3	4.9
S	4.7	4.8	4.6
O	3.7	3.9	4.0
N	2.0	2.1	2.2
D	1.7	1.9	2.0

Location: Jacksonville, FL

Latitude: 30° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.8	4.3	4.3
F	4.9	5.3	5.4
M	5.5	5.6	5.5
A	6.2	6.0	5.5
M	6.4	5.9	5.2
J	5.9	5.4	4.7
J	6.0	5.5	4.9
A	5.5	5.3	4.9
S	4.7	4.7	4.6
O	4.3	4.6	4.6
N	3.7	4.2	4.4
D	3.2	3.7	3.9

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.5	3.6
F	4.0	4.3	4.3
M	5.0	5.1	4.9
A	5.9	5.7	5.2
M	6.3	5.8	5.1
J	6.2	5.7	4.9
J	6.2	5.7	5.0
A	6.0	5.7	5.3
S	5.3	5.3	5.1
O	4.9	5.3	5.3
N	3.5	3.9	4.1
D	3.0	3.3	3.6

Location: Kansas City, MO

Latitude: 39° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.2	3.5	3.7
F	4.0	4.3	4.4
M	4.8	4.9	4.7
A	5.6	5.4	4.9
M	6.0	5.5	4.9
J	6.6	6.0	5.2
J	6.5	6.0	5.3
A	6.3	6.1	5.6
S	5.5	5.6	5.4
O	4.7	5.1	5.2
N	3.5	4.0	4.2
D	2.9	3.3	3.5

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Key West, FL

Latitude: 24° 30'

Location: Lake Charles, LA

Latitude: 30° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.3	4.9	5.1
F	5.3	5.8	5.9
M	6.1	6.3	6.1
A	6.8	6.5	6.0
M	6.7	6.2	5.4
J	6.2	5.7	4.9
J	6.1	5.7	5.0
A	5.8	5.6	5.1
S	5.3	5.4	5.2
O	4.8	5.2	5.3
N	4.2	4.7	5.0
D	3.8	4.3	4.6

Location: Lander, WY

Latitude: 42° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.8	5.6	6.0
F	5.9	6.4	6.5
M	6.9	7.1	6.9
A	7.3	7.0	6.4
M	6.9	6.4	5.6
J	7.5	6.8	5.8
J	7.3	6.8	5.9
A	7.1	6.8	6.2
S	6.4	6.6	6.4
O	5.8	6.3	6.5
N	4.4	5.1	5.5
D	4.1	4.8	5.2

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.3	4.5	4.6
M	5.1	5.2	5.0
A	5.8	5.6	5.1
M	6.3	5.8	5.1
J	6.5	6.0	5.1
J	5.9	5.4	4.8
A	5.9	5.6	5.2
S	5.5	5.6	5.4
O	5.3	5.8	5.9
N	4.1	4.6	4.8
D	3.5	3.7	3.9

Location: Lansing, MI

Latitude: 42° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.5	2.8	2.9
F	3.6	3.8	3.8
M	4.5	4.6	4.4
A	4.6	4.4	4.0
M	5.8	5.3	4.7
J	6.2	5.6	4.9
J	6.2	5.7	5.0
A	5.8	5.5	5.1
S	5.0	5.1	4.9
O	3.9	4.1	4.2
N	2.3	2.6	2.7
D	2.0	2.3	2.4

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Laramie, WY

Latitude: 41° 20'

Location: Las Vegas, NV

Latitude: 36° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.4	5.0	5.4
F	5.1	5.5	5.6
M	6.4	6.6	6.4
A	6.4	6.1	5.6
M	6.3	5.8	5.1
J	7.0	6.3	5.4
J	6.8	6.2	5.4
A	6.3	6.1	5.5
S	5.6	5.7	5.5
O	5.0	5.4	5.5
N	4.0	4.6	4.9
D	3.5	4.1	4.4

Location: Lemont, IL

Latitude: 41° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.5	3.7
F	3.9	4.1	4.2
M	4.7	4.7	4.6
A	4.9	4.7	4.3
M	5.8	5.3	4.7
J	6.2	5.6	4.9
J	6.0	5.5	4.8
A	5.9	5.7	5.2
S	5.1	5.1	5.0
O	3.9	4.2	4.2
N	2.6	2.9	3.0
D	2.3	2.6	2.8

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.8	5.5	5.9
F	6.2	6.8	6.9
M	7.1	7.3	7.1
A	7.8	7.6	6.9
M	8.1	7.4	6.4
J	8.3	7.5	6.4
J	7.6	7.0	6.1
A	7.5	7.2	6.6
S	7.3	7.5	7.3
O	6.3	6.9	7.1
N	5.1	5.9	6.3
D	4.5	5.3	5.8

Location: Lexington, KY

Latitude: 38° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.8	3.2	3.3
F	4.0	4.3	4.3
M	5.1	5.2	5.0
A	6.0	5.7	5.2
M	6.7	6.1	5.4
J	7.0	6.3	5.4
J	7.0	6.4	5.6
A	6.7	6.4	5.9
S	6.4	6.6	6.3
O	5.4	5.8	5.9
N	3.8	4.3	4.5
D	2.9	3.3	3.5

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Lincoln, NE

Latitude: 40° 50'

Location: Little Rock, AR

Latitude: 34° 40'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.5	3.9	4.2
F	4.2	4.5	4.5
M	5.0	5.1	4.9
A	5.4	5.2	4.7
M	5.8	5.3	4.7
J	6.1	5.5	4.8
J	6.1	5.6	4.9
A	6.1	5.9	5.4
S	5.4	5.5	5.3
O	5.0	5.4	5.5
N	3.3	3.9	4.1
D	3.1	3.6	3.9

Location: Los Angeles, CA

Latitude: 33° 60'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.0	4.5	4.8
F	5.1	5.5	5.6
M	6.2	6.4	6.2
A	6.4	6.2	5.7
M	6.6	6.1	5.4
J	6.9	6.3	5.4
J	7.3	6.7	5.9
A	6.9	6.7	6.1
S	6.4	6.5	6.3
O	5.0	5.4	5.5
N	4.3	4.9	5.2
D	3.9	4.5	4.8

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.4	3.5
F	3.8	4.1	4.1
M	4.8	4.9	4.7
A	5.4	5.3	4.9
M	6.1	5.6	5.0
J	6.3	5.7	4.9
J	6.3	5.8	5.1
A	6.0	5.8	5.3
S	5.5	5.6	5.4
O	4.7	5.1	5.1
N	3.6	4.0	4.2
D	2.9	3.2	3.5

Location: Louisville, KY

Latitude: 38° 10'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	3.0	3.1
F	3.4	3.8	3.8
M	4.6	4.6	4.4
A	5.3	5.1	4.7
M	6.0	5.5	4.9
J	6.3	5.7	4.9
J	6.2	5.7	5.0
A	5.9	5.7	5.2
S	5.2	5.3	5.1
O	4.3	4.6	4.7
N	3.0	3.3	3.5
D	2.4	2.7	2.9

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Lynne, MA

Latitude: 47° 30'

Location: Macon, GA

Latitude: 32° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.1	2.3	2.3
F	3.3	3.7	3.7
M	4.4	4.6	4.2
A	5.0	4.8	4.4
M	5.3	4.9	4.3
J	6.0	5.4	4.7
J	6.1	5.6	4.9
A	5.0	4.8	4.4
S	4.4	4.5	4.3
O	3.4	3.6	3.7
N	2.1	2.3	2.4
D	1.7	1.9	2.0

Location: Madison, WI

Latitude: 43° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.4	3.5
F	3.8	4.1	4.1
M	5.0	5.0	4.9
A	5.0	4.8	4.4
M	5.6	5.1	4.5
J	6.2	5.6	4.9
J	6.3	5.8	5.1
A	5.8	5.5	5.0
S	5.3	5.4	5.2
O	4.2	4.5	4.6
N	2.6	2.9	3.0
D	2.6	3.0	3.2

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.7	4.2	4.4
F	4.5	4.8	4.8
M	5.2	5.3	5.1
A	6.2	6.0	5.5
M	6.5	6.0	5.3
J	6.4	5.8	5.0
J	6.2	5.7	5.0
A	6.1	5.8	5.3
S	5.4	5.4	5.2
O	5.0	5.3	5.4
N	3.8	4.3	4.5
D	3.2	3.7	3.9

Location: Manhattan, KA

Latitude: 39° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.2	4.5	4.6
M	4.8	4.9	4.7
A	5.5	5.3	4.8
M	6.1	5.6	4.9
J	6.2	5.6	4.9
J	6.0	5.5	4.8
A	6.3	6.1	5.6
S	5.5	5.4	5.2
O	4.3	4.6	4.6
N	3.8	4.3	4.6
D	2.7	3.0	3.2

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Natanuska, AK

Latitude: 41° 30'

Location: Medford, OR

Latitude: 42° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.8	2.0	2.2
F	3.0	3.2	3.3
M	5.6	5.7	5.6
A	5.6	5.3	4.8
M	5.5	5.0	4.3
J	5.3	4.8	4.1
J	4.8	4.4	3.8
A	4.1	3.9	3.5
S	3.2	3.2	3.1
O	2.3	2.5	2.5
N	1.6	1.6	1.7
D	0.8	0.9	1.0

Location: Memphis, TN

Latitude: 35° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.3	3.4
F	3.9	4.2	4.2
M	4.8	4.9	4.7
A	5.8	5.5	5.1
M	6.4	5.9	5.2
J	6.6	6.0	5.2
J	6.6	6.1	5.3
A	6.4	6.1	5.6
S	5.4	5.7	5.5
O	5.0	5.4	5.5
N	3.6	4.0	4.2
D	2.9	3.2	3.4

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.1	2.3	2.3
F	3.5	3.7	3.7
M	4.9	5.0	4.8
A	6.3	6.0	5.5
M	6.9	6.3	5.5
J	7.3	6.6	5.7
J	8.0	7.3	6.4
A	7.3	7.1	6.4
S	6.1	6.3	6.0
O	4.3	4.6	4.6
N	2.6	2.9	3.0
D	1.5	1.6	1.7

Location: Miami, FL

Latitude: 25° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.7	5.3	5.6
F	5.5	5.9	6.1
M	6.2	6.4	6.2
A	6.4	6.2	5.7
M	6.4	5.9	5.2
J	6.0	5.5	4.8
J	6.1	5.7	5.0
A	5.9	5.7	5.2
S	5.4	5.5	5.3
O	4.9	5.2	5.3
N	4.6	5.2	5.5
D	4.3	4.9	5.3

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Midland, TX

Latitude: 31° 60'

Location: Milwaukee, WI

Latitude: 42° 60'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.2	4.7	5.0
F	5.1	5.5	5.6
M	6.3	6.5	6.3
A	6.8	6.5	6.0
M	7.1	5.5	5.7
J	6.9	6.3	5.4
J	6.9	6.4	5.6
A	6.9	5.7	6.1
S	6.4	6.5	6.3
O	5.4	5.8	5.9
N	4.6	5.2	5.5
D	4.1	4.8	5.2

Location: Minneapolis-
St. Paul, MN

Latitude: 44° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.3	3.4
F	3.9	4.2	4.3
M	4.6	4.7	4.5
A	5.1	4.9	4.5
M	5.7	5.2	4.6
J	6.0	5.4	4.7
J	6.2	5.7	5.0
A	5.6	5.4	4.9
S	4.9	5.0	4.8
O	4.1	4.4	4.4
N	2.5	2.8	2.9
D	2.2	2.5	2.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.8	3.1	3.3
F	3.5	3.8	3.8
M	4.5	4.6	4.4
A	5.1	4.9	4.5
M	5.9	5.4	4.8
J	6.3	5.7	5.0
J	6.4	5.9	5.2
A	5.9	5.6	5.1
S	5.2	5.3	5.1
O	4.0	4.3	4.4
N	2.7	3.1	3.2
D	2.2	2.5	2.6

Location: Mt. Weather, VA

Latitude: 39° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.3	3.4
F	4.4	4.8	4.8
M	4.7	4.8	4.6
A	5.2	5.0	4.5
M	5.9	5.4	4.8
J	5.9	5.3	4.6
J	5.8	5.3	4.7
A	5.1	4.9	4.5
S	4.8	4.9	4.7
O	4.1	4.4	4.4
N	3.2	3.6	3.8
D	2.9	3.3	3.5

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Nashville, TN

Latitude: 36° 10'

Location: Watck, MA

Latitude: 42° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.5	2.8	2.9
F	3.6	3.8	3.9
M	4.5	4.6	4.4
A	5.5	5.3	4.9
M	6.0	5.5	4.9
J	6.4	5.8	5.0
J	6.2	5.7	5.0
A	5.8	5.4	5.1
S	5.4	5.5	5.3
O	4.6	4.9	5.0
N	3.3	3.7	3.8
D	2.5	2.8	3.0

Location: New Orleans, LA

Latitude: 29° 00'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.3	3.4
F	3.5	3.7	3.7
M	4.3	4.4	4.2
A	4.9	4.8	4.4
M	5.1	4.8	4.2
J	5.0	4.6	4.1
J	4.8	4.6	4.3
A	4.8	4.6	4.3
S	4.6	4.6	4.5
O	4.6	4.9	5.0
N	3.7	4.2	4.4
D	2.7	3.1	3.3

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.8	3.1	3.3
F	3.9	4.2	4.2
M	4.8	4.8	4.7
A	5.0	4.8	4.4
M	5.8	5.3	4.7
J	4.5	4.1	3.6
J	5.8	5.3	4.7
A	5.4	5.2	4.8
S	4.7	4.8	4.6
O	4.0	4.3	4.3
N	2.4	2.7	2.8
D	2.5	2.9	3.0

Location: Newport, RI

Latitude: 41° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.8	3.1	3.2
F	3.8	4.0	4.1
M	4.8	4.9	4.7
A	5.0	4.8	4.4
M	5.7	5.2	4.6
J	6.0	5.4	4.7
J	5.9	5.4	4.8
A	5.3	5.1	4.7
S	5.0	5.0	4.8
O	4.1	4.4	4.4
N	2.9	3.2	3.4
D	2.5	2.9	3.1

NWC TP 6381

INSOLATION

(kWh/m²)

Location: New York, NY

Latitude: 40° 50'

Location: Norfolk, VA

Latitude: 36° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.2	2.4	2.5
F	3.1	3.3	3.3
M	4.1	4.1	4.0
A	4.6	4.6	4.1
M	5.0	4.6	4.1
J	5.3	4.9	4.2
J	5.2	4.8	4.3
A	4.6	4.4	4.0
S	4.3	4.3	4.1
O	3.5	3.7	3.7
N	2.2	2.5	2.6
D	1.9	2.1	2.2

Location: North Omaha, NE

Latitude: 41° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.0	4.5	4.8
F	4.7	5.1	5.2
M	5.2	5.3	5.1
A	5.9	5.7	5.2
M	6.0	5.5	4.9
J	6.3	5.7	4.9
J	6.4	5.9	5.2
A	6.3	6.1	5.5
S	5.3	5.4	5.2
O	4.5	4.8	4.9
N	3.4	3.8	4.0
D	3.1	3.6	3.9

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.1	4.4	4.5
M	5.1	5.2	5.0
A	6.0	5.8	5.3
M	6.2	5.8	5.0
J	6.4	5.8	5.0
J	6.2	5.7	5.0
A	5.7	5.5	5.0
S	5.1	5.1	5.0
O	4.4	4.7	4.7
N	3.4	3.8	4.0
D	3.0	3.4	3.6

Location: Oak Ridge, TN

Latitude: 36° 0'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.6	2.9	3.0
F	3.5	3.7	3.8
M	4.4	4.5	4.3
A	5.5	5.3	4.9
M	5.9	5.4	4.8
J	6.1	5.5	4.8
J	5.9	5.4	4.8
A	5.6	5.4	4.9
S	5.3	5.4	5.2
O	4.5	4.8	4.9
N	3.1	3.5	3.6
D	2.5	2.8	3.0

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Oklahoma City, OK

Latitude: 35° 20'

Location: Page, AZ

Latitude: 36° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.1	4.7	5.0
F	4.8	5.2	5.3
M	5.6	5.7	5.5
A	6.2	6.0	5.5
M	6.2	5.7	5.0
J	7.0	6.4	5.5
J	6.8	6.3	5.5
A	7.0	6.8	6.2
S	6.1	6.3	6.1
O	5.4	5.8	5.9
N	4.5	5.0	5.3
D	3.9	4.5	4.9

Location: Parkersburg, WV

Latitude: 39° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.3	2.4	2.7
F	3.2	3.3	3.3
M	4.2	4.3	4.1
A	4.8	4.6	4.2
M	5.7	5.2	4.6
J	6.1	5.5	4.8
J	6.0	5.5	4.8
A	5.8	5.6	5.1
S	5.1	5.2	5.0
O	4.1	4.4	4.4
N	2.6	2.9	3.0
D	2.2	2.4	2.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	5.3	6.1	6.6
F	6.2	6.7	6.9
M	7.6	7.8	7.6
A	7.8	7.6	6.9
M	8.1	7.4	6.5
J	7.9	7.2	6.1
J	7.7	7.1	6.2
A	7.1	6.9	6.3
S	6.7	6.9	6.7
O	5.9	6.4	6.6
N	5.0	5.7	6.1
D	4.1	4.8	5.3

Location: Pasadena, CA

Latitude: 34° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.9	4.4	4.7
F	5.0	5.4	5.5
M	6.0	6.1	5.9
A	6.3	6.1	5.6
M	6.5	6.0	5.3
J	6.5	5.9	5.1
J	7.2	6.6	5.8
A	7.1	6.9	6.3
S	6.1	6.2	6.0
O	5.0	5.4	5.5
N	4.0	4.5	4.8
D	3.7	4.3	4.6

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Pensacola, FL

Latitude: 30° 30'

Location: Peoria, IL

Latitude: 40° 40'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.6	4.0	4.2
F	4.5	4.8	4.9
M	5.2	5.3	5.1
A	6.2	6.0	5.5
H	6.4	5.9	5.2
J	6.3	5.8	5.0
J	6.1	5.6	5.0
A	6.0	5.8	5.3
S	5.3	5.4	5.2
O	5.2	5.6	5.7
H	3.8	4.3	4.5
D	3.7	3.4	3.8

Location: Phoenix, AZ

Latitude: 33° 30'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.7	5.4	5.7
F	6.2	5.7	6.9
M	7.2	7.4	7.2
A	8.0	7.7	7.0
H	8.3	7.6	6.6
J	8.2	7.4	6.3
J	7.4	6.8	5.9
A	7.2	7.0	6.4
S	7.2	7.4	7.2
O	6.3	6.9	7.1
H	5.1	5.9	6.3
D	4.5	5.2	5.7

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	3.6	3.9	3.9
M	4.6	4.7	4.5
A	5.4	5.2	4.7
H	5.9	5.4	4.8
J	6.4	5.8	5.0
J	6.4	5.9	5.2
A	6.0	5.8	5.3
S	5.4	5.5	5.3
O	4.5	4.8	4.9
H	3.0	3.4	3.5
D	2.4	2.7	2.9

Location: Philadelphia, PA

Latitude: 39° 50'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.4	3.6
F	3.8	4.1	4.1
M	4.9	5.0	4.8
A	5.4	5.2	4.7
H	5.7	5.2	4.6
J	6.2	5.6	4.9
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	5.0	5.1	4.9
O	4.2	4.6	4.6
H	3.0	3.4	3.6
D	2.6	3.0	3.2

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Pittsburgh, PA

Latitude: 40° 30'

Location: Pocatello, ID

Latitude: 42° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	3.0	3.2
F	3.4	3.6	3.4
M	4.6	4.7	4.5
A	5.1	4.9	4.4
M	5.7	5.2	4.6
J	6.3	5.7	4.9
J	6.2	5.7	5.0
A	5.8	5.6	5.1
S	5.3	5.4	5.2
O	4.4	4.7	4.8
N	3.0	3.4	3.5
D	2.5	2.8	3.0

Location: Port Arthur, TX

Latitude: 29° 60'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.2	3.6	3.7
F	4.1	4.3	4.4
M	4.9	5.0	4.8
A	5.3	5.1	4.7
M	6.2	5.8	5.1
J	6.4	5.9	5.1
J	6.0	5.5	4.9
A	5.6	5.5	5.0
S	5.3	5.4	5.2
O	4.9	5.3	5.4
N	3.4	3.8	4.0
D	3.0	3.3	3.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.2	3.6	3.7
F	4.3	4.6	4.7
M	5.5	5.6	5.4
A	6.8	6.6	6.0
M	6.8	6.3	5.5
J	7.3	6.6	5.7
J	7.7	7.1	6.1
A	7.2	7.0	6.3
S	6.5	6.7	6.5
O	5.3	5.7	5.9
N	3.7	4.2	4.5
D	3.0	3.5	3.8

Location: Portland, ME

Latitude: 43° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.5	3.7
F	4.2	4.5	4.5
M	5.5	5.6	5.4
A	5.2	5.0	4.6
M	6.0	5.5	4.8
J	6.1	5.5	4.8
J	6.3	5.8	5.1
A	5.9	5.6	5.1
S	5.1	5.2	5.0
O	4.3	4.6	4.7
N	2.7	3.0	3.2
D	2.7	3.1	3.3

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Portland, OR

Latitude: 45° 40'

Location: Prosser, WA

Latitude: 46° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.8	1.9	2.0
F	2.7	2.8	2.8
M	3.6	3.4	3.4
A	4.6	4.4	4.0
M	5.0	4.6	4.0
J	5.3	4.8	4.2
J	6.3	5.8	5.1
A	5.4	5.2	4.7
S	4.7	4.7	4.5
O	3.1	3.2	3.3
N	2.0	2.2	2.3
D	1.5	1.7	1.8

Location: Pueblo, CO

Latitude: 38° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	5.0	5.7	6.1
F	5.8	6.3	6.5
M	6.5	6.6	6.4
A	7.0	6.7	6.1
M	7.0	6.4	5.6
J	7.5	6.8	5.8
J	7.3	6.7	5.9
A	7.2	7.0	6.4
S	6.6	6.8	6.6
O	5.9	6.5	6.6
N	5.0	5.8	6.2
D	4.4	5.2	5.6

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.4	2.7	2.8
F	4.2	4.5	4.5
M	5.6	5.8	5.6
A	7.0	6.7	6.1
M	7.4	6.8	5.9
J	7.7	6.9	5.9
J	8.1	7.5	6.5
A	7.7	7.4	6.7
S	6.7	6.9	6.7
O	4.7	5.1	5.1
N	2.5	2.8	3.0
D	2.0	2.3	2.5

Location: Pullman, WA

Latitude: 46° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.6	2.9	3.0
F	3.3	3.5	3.6
M	4.7	4.7	4.5
A	6.1	5.9	5.3
M	6.5	5.9	5.2
J	7.7	6.9	5.9
J	8.2	7.5	6.5
A	6.9	6.6	6.0
S	6.1	6.3	6.1
O	4.3	4.6	4.7
N	2.8	3.2	3.4
D	1.9	2.2	2.3

NWC TP 6381

INSOLATION
(kWh/m²)

Location: Put-In-Bay, OH

Latitude: 41° 40'

Location: Raleigh, NC

Latitude: 35° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.0	2.2	2.3
F	3.2	3.4	3.4
M	4.2	4.2	4.0
A	4.7	4.5	4.1
M	5.8	5.3	4.7
J	6.1	5.5	4.8
J	6.4	5.9	5.2
A	6.2	6.0	5.5
S	5.3	5.4	5.2
O	4.5	4.8	4.9
N	2.6	2.9	3.0
D	1.9	2.1	2.2

Location: Raleigh-Durham, NC

Latitude: 35° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.5	3.9	4.1
F	4.3	4.6	4.6
M	5.1	5.2	5.0
A	6.0	5.8	5.3
M	6.0	5.6	4.9
J	6.0	5.4	4.7
J	6.2	5.7	5.0
A	5.7	5.5	5.0
S	5.0	5.1	4.9
O	4.4	4.7	4.8
N	3.6	4.0	4.3
D	3.1	3.5	3.8

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.9	4.4	4.6
F	4.6	5.0	5.1
M	5.5	5.6	5.5
A	5.9	5.7	5.2
M	5.8	5.4	4.7
J	6.4	5.8	5.0
J	6.1	5.6	4.9
A	5.7	5.5	5.0
S	4.9	4.9	4.8
O	4.3	4.6	4.7
N	3.6	4.0	4.3
D	3.2	3.7	4.0

Location: Rapid City, SD

Latitude: 44° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.0	4.6	4.8
F	5.2	5.7	5.8
M	6.2	6.4	6.2
A	6.3	6.1	5.6
M	6.3	5.8	5.1
J	6.7	6.0	5.2
J	6.8	6.2	5.4
A	6.6	6.4	5.8
S	6.0	6.1	5.9
O	5.1	5.6	5.7
N	4.0	4.5	4.8
D	3.3	3.9	4.2

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Reno, NV

Latitude: 39° 30'

Location: Richland, WA

Latitude: 46° 20'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.3	4.9	5.2
F	5.4	5.8	6.0
M	6.5	6.7	6.5
A	7.6	7.3	6.7
M	7.8	7.2	6.2
J	8.0	7.2	6.1
J	8.0	7.3	6.4
A	7.8	7.5	6.9
S	7.1	7.4	7.1
O	6.1	6.7	6.9
N	4.8	5.5	5.9
D	3.8	4.5	4.8

Location: Richmond, VA

Latitude: 37° 50'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.5	3.7
F	3.9	4.2	4.2
M	5.0	5.1	4.9
A	5.7	5.5	5.1
M	6.0	5.6	4.9
J	6.3	5.7	5.0
J	6.3	5.8	5.1
A	5.7	5.5	5.0
S	5.0	5.1	4.9
O	4.3	4.6	4.7
N	3.2	3.6	3.8
D	2.8	3.2	3.4

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.6	1.7	1.8
F	3.7	3.9	4.0
M	5.2	5.3	5.1
A	6.2	6.0	5.4
M	6.1	5.6	4.9
J	7.2	6.5	5.6
J	6.6	6.0	5.3
A	7.5	7.3	6.6
S	5.5	5.6	5.4
O	3.7	4.0	4.0
N	2.2	2.5	2.6
D	2.0	2.3	2.4

Location: Riverside, CA

Latitude: 33° 60'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.3	4.9	5.3
F	5.5	5.9	6.0
M	6.5	6.7	6.5
A	6.6	6.4	5.9
M	7.2	6.6	5.8
J	7.6	6.9	5.9
J	7.6	7.0	6.1
A	7.3	7.1	6.5
S	6.8	7.0	6.7
O	5.7	6.2	6.3
N	4.8	5.3	5.9
D	4.3	5.0	5.4

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Rochester, NY

Latitude: 43° 10'

Location: Sacramento, CA

Latitude: 38° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.5	2.8	3.0
F	3.4	3.6	3.6
M	4.4	4.5	4.3
A	5.1	4.9	4.5
M	6.0	5.5	4.8
J	6.4	5.8	5.0
J	6.5	6.0	5.3
A	6.0	5.7	5.2
S	5.0	5.1	4.9
O	3.8	4.1	4.2
N	2.5	2.7	2.9
D	2.1	2.4	2.5

Location: St. Cloud, MN

Latitude: 45° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.7	4.3	4.5
F	4.8	5.1	5.2
M	5.8	5.9	5.7
A	5.6	5.3	4.8
M	5.9	5.4	4.7
J	6.1	5.5	4.8
J	6.3	5.8	5.1
A	6.1	5.8	5.3
S	5.0	5.1	4.9
O	3.8	4.1	4.2
N	2.7	3.0	3.2
D	2.6	3.0	3.2

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.7	2.9	3.1
F	4.2	4.5	4.5
M	5.7	5.8	5.6
A	6.7	6.5	5.9
M	7.9	7.2	6.3
J	7.6	6.9	5.9
J	7.8	7.1	6.2
A	7.0	6.8	6.2
S	6.4	6.5	6.3
O	5.4	5.9	6.0
N	3.6	4.0	4.3
D	2.5	2.8	3.0

Location: St. Louis, MO

Latitude: 38° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.0	3.3	3.5
F	3.9	4.1	4.2
M	4.9	4.9	4.7
A	5.4	5.2	4.7
M	6.1	5.6	5.0
J	6.4	5.8	5.0
J	6.4	5.9	5.2
A	5.9	5.7	5.2
S	5.4	5.5	5.3
O	4.5	4.8	4.9
N	3.3	3.7	3.9
D	2.5	2.9	3.1

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Salt Lake City, UT

Latitude: 40° 50'

Location: San Antonio, TX

Latitude: 29° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	4.2	4.5	4.5
M	5.1	5.2	5.0
A	6.2	5.9	5.4
M	6.7	6.2	5.6
J	7.0	6.3	5.6
J	7.0	6.4	5.4
A	6.7	6.4	5.9
S	5.9	6.1	5.9
O	4.8	5.2	5.2
N	3.4	3.8	4.0
D	2.6	2.9	3.1

Location: San Diego, CA

Latitude: 32° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.1	4.6	4.9
F	5.0	5.4	5.5
M	5.7	5.8	5.6
A	5.7	5.5	5.0
M	5.7	5.3	4.6
J	5.7	5.2	4.5
J	6.2	5.7	5.0
A	5.8	5.9	5.2
S	5.6	5.7	5.5
O	4.9	5.2	5.3
N	4.0	4.6	4.8
D	3.7	4.3	4.9

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.0	4.4	4.7
F	4.8	5.2	5.3
M	5.5	5.6	5.4
A	5.4	5.2	4.8
M	6.2	5.7	5.1
J	6.8	6.2	5.3
J	7.0	6.5	5.7
A	4.8	6.6	6.0
S	6.0	6.1	5.9
O	5.1	5.6	5.7
N	3.9	4.4	4.7
D	3.5	4.0	4.3

Location: San Francisco, CA

Latitude: 37° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.2	3.6	3.8
F	4.4	4.7	4.8
M	5.7	5.8	5.6
A	6.4	6.2	5.6
M	6.7	6.2	5.4
J	6.7	6.1	5.3
J	6.1	5.6	4.9
A	5.7	5.5	5.0
S	5.5	5.6	5.4
O	4.8	5.2	5.3
N	3.6	4.1	4.3
D	2.9	3.3	3.5

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Santa Maria, CA

Latitude: 34° 59'

Location: Savannah, GA

Latitude: 32° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.2	4.8	5.1
F	5.3	5.8	5.9
M	6.7	6.9	6.7
A	7.0	6.7	6.1
M	7.3	6.7	5.9
J	7.8	7.1	6.0
J	7.7	7.1	6.2
A	7.2	7.0	6.4
S	6.7	6.8	6.6
O	5.9	6.5	6.6
N	4.8	5.5	5.9
D	4.1	4.7	5.1

Location: Sault St. Marie, MI

Latitude: 46° 30'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.8	3.2	3.3
F	4.3	4.7	4.7
M	5.7	5.9	5.7
A	5.5	5.3	4.8
M	6.2	5.7	5.0
J	6.2	5.6	4.8
J	6.6	6.0	5.3
A	5.8	5.6	5.1
S	4.4	4.5	4.3
O	3.5	3.7	3.7
N	1.8	2.0	2.0
D	2.0	2.2	2.4

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.7	4.1	4.3
F	4.5	4.8	4.8
M	5.3	5.4	5.2
A	6.3	6.1	5.6
M	6.4	5.9	5.2
J	6.2	5.7	4.9
J	6.1	5.6	4.9
A	5.8	5.6	5.2
S	5.0	5.0	4.8
O	4.6	4.9	5.0
N	3.7	4.2	4.4
D	3.2	3.6	3.9

Location: Schenectady, NY

Latitude: 42° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.3	2.6	2.7
F	3.3	3.5	3.5
M	3.9	4.0	3.8
A	4.3	4.1	3.7
M	4.8	4.4	3.9
J	5.0	4.6	4.0
J	5.0	4.6	4.1
A	4.8	4.6	4.2
S	3.9	3.9	3.8
O	3.2	3.4	3.5
N	2.0	2.2	2.3
D	1.8	2.0	2.1

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Seattle, WA

Latitude: 47° 30'

Location: Shreveport, LA

Latitude: 32° 20'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	1.5	1.6	1.7
F	2.3	2.4	2.4
M	4.1	4.2	4.0
A	5.3	5.1	4.6
M	5.9	5.6	4.7
J	5.9	5.3	4.6
J	6.4	5.9	5.2
A	5.8	5.6	5.1
S	4.5	4.5	4.4
O	3.0	3.2	3.2
N	1.9	2.1	2.2
D	1.4	1.6	1.7

Location: Silver Hill, MD

Latitude: 38° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.5	3.4
F	3.8	4.0	4.1
M	4.7	4.8	4.6
A	5.5	5.3	4.8
M	5.9	5.4	4.8
J	6.2	5.6	4.9
J	5.9	5.6	4.8
A	5.5	5.3	4.8
S	5.1	5.2	5.0
O	4.2	4.5	4.5
N	3.2	3.5	3.7
D	2.7	3.1	3.3

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.7	3.9
F	4.0	4.3	4.3
M	5.0	5.1	4.9
A	5.7	5.5	5.0
M	6.3	5.8	5.1
J	6.1	5.6	4.9
J	6.3	5.8	5.1
A	6.1	5.8	5.3
S	5.2	5.2	5.0
O	4.6	4.9	5.0
N	3.4	3.8	4.0
D	2.9	3.3	3.5

Location: Spokane, WA

Latitude: 47° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.6	2.9	3.1
F	4.2	4.5	4.6
M	5.1	5.2	5.0
A	6.3	6.1	5.5
M	6.6	6.0	5.3
J	6.8	6.1	5.3
J	7.7	7.1	6.1
A	7.0	6.7	6.1
S	5.9	6.0	5.8
O	3.3	3.5	3.6
N	2.5	2.8	3.0
D	1.5	1.7	1.8

NWC TP 6381

INSOLATION
(kWh/m²)

Location: State College, PA

Latitude: 40° 50'

Location: Stillwater, OK

Latitude: 36° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.3	2.6	2.7
F	3.2	3.4	3.4
M	4.2	4.2	4.1
A	4.7	4.5	4.1
M	5.5	5.0	4.4
J	6.1	5.5	4.8
J	6.0	5.3	4.9
A	5.5	5.2	4.8
S	4.7	4.7	4.5
O	4.0	4.3	4.4
N	2.5	2.7	2.9
D	2.0	2.3	2.4

Location: Summit, NY

Latitude: 48° 50'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	3.1	3.3	3.3
M	4.2	4.3	4.1
A	5.4	5.4	4.9
M	5.4	5.0	4.4
J	5.3	5.0	4.3
J	6.4	5.9	5.2
A	6.4	6.1	5.4
S	5.0	5.1	4.9
O	3.4	3.9	3.9
N	1.9	2.1	2.2
D	1.4	1.8	1.9

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.4	4.7	4.7
M	5.3	5.4	5.2
A	5.4	5.4	5.0
M	5.8	5.3	4.7
J	6.4	6.0	5.2
J	6.7	6.2	5.4
A	6.5	6.2	5.7
S	5.8	5.9	5.7
O	4.9	5.3	5.4
N	4.0	4.5	4.8
D	3.3	3.8	4.1

Location: Syracuse, NY

Latitude: 43° 10'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.4	2.7	2.8
F	3.2	3.4	3.4
M	4.2	4.3	4.1
A	4.8	4.6	4.2
M	5.7	5.2	4.6
J	6.2	5.6	4.9
J	6.3	5.8	5.1
A	5.7	5.4	4.9
S	4.8	4.9	4.7
O	3.7	3.9	3.9
N	2.0	2.3	2.3
D	1.9	2.1	2.1

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Tallahassee, FL

Latitude: 30° 30'

Location: Tampa, FL

Latitude: 27° 40'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.3	3.9	4.1
F	4.3	4.6	4.7
M	5.3	5.6	5.5
A	5.8	5.6	5.1
M	6.3	5.8	5.1
J	5.4	4.9	4.3
J	6.2	5.7	5.0
A	6.3	6.1	5.5
S	5.2	5.3	5.1
O	4.6	4.9	5.0
N	5.1	5.9	6.3
D	4.7	5.4	5.9

Location: Trenton, NJ

Latitude: 40° 10'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.1	3.4	3.6
F	3.9	4.2	4.2
M	4.9	5.0	4.8
A	5.4	5.2	4.7
M	5.7	5.2	4.6
J	6.1	5.3	4.8
J	6.1	5.6	4.9
A	5.6	5.4	4.9
S	5.1	5.2	5.0
O	4.3	4.7	4.7
N	3.2	3.6	3.8
D	2.8	3.1	3.4

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.6	5.2	5.5
F	5.3	5.8	5.9
M	6.1	6.2	6.0
A	6.6	6.3	5.8
M	6.8	6.3	5.6
J	6.4	5.9	5.1
J	6.1	5.6	5.0
A	5.8	5.6	5.1
S	5.4	5.5	5.3
O	5.2	5.6	5.7
N	4.8	5.5	5.8
D	4.2	4.8	5.2

Location: Tucson, AZ

Latitude: 32° 10'

TILT ANGLE			
MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.9	5.5	5.9
F	5.9	6.4	6.6
M	7.4	7.6	7.4
A	8.2	7.9	7.2
M	8.5	7.8	6.8
J	7.9	7.1	6.1
J	7.0	6.5	5.7
A	6.9	6.7	6.1
S	7.3	7.6	7.3
O	6.1	6.7	6.9
N	5.3	6.0	6.5
D	4.6	5.4	5.8

NWC TP 6381

IMBOLATION

(kWh/m²)

Location: Tulsa, OK

Latitude: 36° 10'

Location: Twin Falls, ID

Latitude: 40° 30'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.4	3.8	4.0
F	4.2	4.4	4.5
M	5.1	5.2	5.0
A	5.4	5.2	4.8
N	6.0	5.5	4.9
J	6.5	5.8	5.1
J	6.4	5.9	5.2
A	6.3	6.0	5.5
S	5.6	5.7	5.5
O	4.7	5.0	5.1
H	3.6	4.0	4.3
D	3.2	3.6	3.9

Location: Washington, DC

Latitude: 38° 50'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.6	2.9	3.1
F	3.5	3.7	3.8
M	4.6	4.5	4.3
A	5.1	4.9	4.5
N	5.1	4.7	4.2
J	6.2	5.4	4.9
J	6.0	5.5	4.9
A	5.5	5.3	4.8
S	4.7	4.8	4.6
O	4.0	4.3	4.3
H	3.3	3.7	3.9
D	2.4	2.7	2.9

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	2.9	3.2	3.4
F	3.9	4.2	4.2
M	5.1	5.2	5.0
A	5.9	5.7	5.2
N	6.4	5.9	5.2
J	6.6	6.0	5.2
J	6.9	6.3	5.3
A	6.6	6.3	5.8
S	5.7	5.8	5.6
O	4.2	4.5	4.6
H	2.9	3.2	3.4
D	2.3	2.5	2.7

Location: Wichita, KS

Latitude: 37° 40'

TILT ANGLE

NORTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	3.8	4.3	4.5
F	4.5	4.8	4.9
M	5.3	5.4	5.2
A	6.0	5.7	5.2
N	6.3	5.8	5.1
J	6.7	6.1	5.3
J	6.6	6.1	5.4
A	6.5	6.2	5.7
S	5.8	5.9	5.7
O	5.0	5.4	5.5
H	3.9	4.5	4.7
D	3.3	3.8	4.1

NWC TP 6381

INSOLATION

(kWh/m²)

Location: Yuma, AZ

Latitude: 32° 40'

TILT ANGLE

MONTH	LATITUDE -15°	LATITUDE	LATITUDE +15°
J	4.7	5.6	5.8
F	6.0	6.5	6.7
M	7.0	7.2	7.0
A	7.8	7.6	6.9
M	8.0	7.4	6.4
J	7.9	7.1	6.1
J	7.6	6.8	5.9
A	6.9	6.7	6.1
S	6.7	6.9	6.7
O	6.1	6.7	6.8
N	4.9	5.6	6.0
D	4.2	4.8	5.2

NWC TP 6381

Appendix E

STORAGE BATTERY
SPECIFICATION SHEET

NWC TP 6381

Volts	Cut-off Voltage	Amp. Hr. Capacity	Current Rate Amps	Specific Gravity		Plates Per Cell	Plate Dimensions in Inches				
				Chgd.	Disch.		Width	Height	Positive Thickness	Negative Thickness	End Neg.
6	1.90	200	0.5	1.300	1.120	5	5 1/2	5 1/2	1 1/2	3/4	1 1/2
	1.75	220	0.5	1.300	1.110		14.3	13.3	1.5	1.5	0.8

Part No.	Description	Overall Battery Dimensions in Inches			Net Weight in Pounds	Terminal Hole Diameter in Inches
		Length	Width	Height		
4118	Standard	16 1/2	7 1/4	9 1/2	76	3/32
5780	With spill-proof vents	16 1/2	7 1/4	9 1/2	76	3/32
9195	In square steel cans	16 1/2	7 1/4	10 1/2	80	3/32
4500	Epoxy sealed	16 1/2	7 1/4	9 1/2	76	3/32

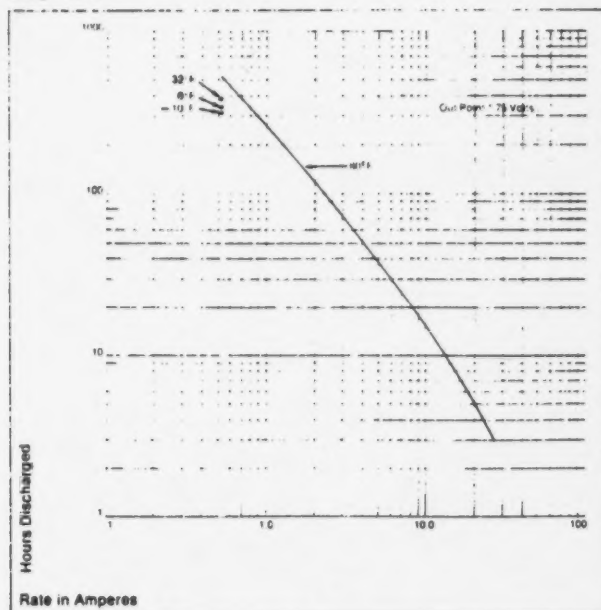
Part No.	Description	Overall Battery Dimensions in Centimeters			Net Weight in Kilograms	Terminal Hole Diameter in Centimeters
		Length	Width	Height		
4118	Standard	40.9	17.9	24.1	34.5	0.7
5780	With spill-proof vents	40.9	17.9	24.1	34.5	0.7
9195	In square steel cans	43	19.4	26.7	36.3	0.7
4500	Epoxy sealed	40.9	17.9	24.1	34.5	0.7

Recommended Charging Voltages

For minimum water loss 2.30 volts/cell
For maximum recharge 2.40 volts/cell

Electrolyte level should be
3/8" (2.2 cm) above the battery plates.

Use potable odorless water for
filling to this level.

Design Curve

NWC TP 6381

Appendix F

INFLATION-DISCOUNT FACTORS²

In these tables, the single-amount factors are to be applied to one-time costs occurring in isolated years. Cumulative-uniform-series factors are to be applied to identical annually recurrent cash flows. The table numbers correspond to the Differential Inflation Rate.

² Naval Facilities Engineering Command. *Economic Analysis Handbook*. Alexandria, Va., NAVFAC, June 1975. Pp. E-1-E-17. (NAVFAC P-442, publication UNCLASSIFIED.)

NWC TP 6381

Table -5PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -5%

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.933	0.933
2	0.812	1.745
3	0.706	2.450
4	0.614	3.064
5	0.534	3.598
6	0.464	4.062
7	0.403	4.465
8	0.351	4.816
9	0.305	5.121
10	0.265	5.386
11	0.231	5.617
12	0.201	5.818
13	0.174	5.992
14	0.152	6.144
15	0.132	6.276
16	0.115	6.390
17	0.100	6.490
18	0.087	6.577
19	0.075	6.652
20	0.066	6.718
21	0.057	6.775
22	0.050	6.824
23	0.043	6.868
24	0.037	6.905
25	0.033	6.938
26	0.028	6.966
27	0.025	6.991
28	0.021	7.012
29	0.019	7.031
30	0.016	7.047

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 5% slower than general price levels.

NWC TP 6381

Table -4PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -4%*
Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.937	0.937
2	0.822	1.759
3	0.721	2.481
4	0.633	3.113
5	0.555	3.668
6	0.487	4.155
7	0.427	4.582
8	0.374	4.956
9	0.329	5.285
10	0.288	5.573
11	0.253	5.826
12	0.222	6.048
13	0.195	6.242
14	0.171	6.413
15	0.150	6.563
16	0.131	6.694
17	0.115	6.809
18	0.101	6.910
19	0.089	6.999
20	0.078	7.077
21	0.068	7.145
22	0.060	7.205
23	0.052	7.257
24	0.046	7.303
25	0.040	7.344
26	0.035	7.379
27	0.031	7.410
28	0.027	7.437
29	0.024	7.461
30	0.021	7.482

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 4% slower than general price levels.

NWC TP 6381

Table -3PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -3%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.941	0.941
2	0.833	1.774
3	0.737	2.511
4	0.652	3.164
5	0.577	3.741
6	0.511	4.252
7	0.452	4.704
8	0.400	5.104
9	0.354	5.458
10	0.313	5.772
11	0.277	6.049
12	0.245	6.294
13	0.217	6.512
14	0.192	6.704
15	0.170	6.874
16	0.151	7.024
17	0.133	7.158
18	0.118	7.275
19	0.104	7.380
20	0.092	7.472
21	0.082	7.554
22	0.073	7.626
23	0.064	7.690
24	0.057	7.747
25	0.050	7.797
26	0.044	7.841
27	0.039	7.880
28	0.035	7.915
29	0.031	7.946
30	0.027	7.973

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 3% slower than general price levels.

NWC TP 6381

Table -2PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -2%*
Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.945	0.945
2	0.844	1.790
3	0.754	2.543
4	0.673	3.216
5	0.601	3.817
6	0.536	4.353
7	0.479	4.832
8	0.428	5.260
9	0.382	5.642
10	0.341	5.983
11	0.304	6.287
12	0.272	6.559
13	0.243	6.802
14	0.217	7.018
15	0.193	7.212
16	0.173	7.385
17	0.154	7.539
18	0.137	7.676
19	0.123	7.799
20	0.110	7.909
21	0.098	8.007
22	0.088	8.095
23	0.078	8.173
24	0.070	8.243
25	0.062	8.305
26	0.056	8.360
27	0.050	8.410
28	0.044	8.454
29	0.040	8.494
30	0.035	8.529

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 2% slower than general price levels.

NWC TP 6381

Table -1PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -1%*
Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.950	0.950
2	0.855	1.805
3	0.771	2.576
4	0.694	3.270
5	0.626	3.896
6	0.564	4.459
7	0.508	4.967
8	0.457	5.424
9	0.412	5.836
10	0.371	6.207
11	0.334	6.542
12	0.301	6.843
13	0.271	7.115
14	0.245	7.359
15	0.220	7.579
16	0.198	7.778
17	0.179	7.957
18	0.161	8.118
19	0.145	8.263
20	0.131	8.394
21	0.118	8.511
22	0.106	8.618
23	0.096	8.713
24	0.086	8.799
25	0.078	8.877
26	0.070	8.947
27	0.063	9.010
28	0.057	9.066
29	0.051	9.118
30	0.046	9.164

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 1% slower than general price levels.

NWC TP 6381

Table 0

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 0%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.954	0.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.977
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.405	6.447
11	0.368	6.815
12	0.334	7.149
13	0.304	7.453
14	0.276	7.729
15	0.251	7.980
16	0.228	8.209
17	0.208	8.416
18	0.189	8.605
19	0.172	8.777
20	0.156	8.933
21	0.142	9.074
22	0.129	9.203
23	0.117	9.320
24	0.107	9.427
25	0.097	9.524
26	0.088	9.612
27	0.080	9.692
28	0.073	9.765
29	0.066	9.831
30	0.060	9.891

* These factors are to be applied to cost elements which are anticipated to escalate at the same rate as the general price level.

NWC TP 6381

Table 1PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 1%
Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.959	0.959
2	0.880	1.839
3	0.808	2.647
4	0.742	3.389
5	0.681	4.070
6	0.626	4.695
7	0.574	5.270
8	0.527	5.797
9	0.484	6.281
10	0.445	6.726
11	0.408	7.134
12	0.375	7.509
13	0.344	7.853
14	0.316	8.169
15	0.290	8.459
16	0.266	8.726
17	0.245	8.970
18	0.225	9.195
19	0.206	9.401
20	0.189	9.590
21	0.174	9.764
22	0.160	9.924
23	0.147	10.070
24	0.135	10.205
25	0.124	10.328
26	0.113	10.442
27	0.104	10.546
28	0.096	10.642
29	0.088	10.730
30	0.081	10.810

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 1% faster than general price levels.

NWC TP 6381

Table 2PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 2%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.963	0.963
2	0.893	1.856
3	0.828	2.684
4	0.768	3.452
5	0.712	4.165
6	0.660	4.825
7	0.612	5.437
8	0.568	6.005
9	0.526	6.531
10	0.488	7.020
11	0.453	7.472
12	0.420	7.892
13	0.389	8.281
14	0.361	8.642
15	0.335	8.977
16	0.310	9.287
17	0.288	9.575
18	0.267	9.842
19	0.247	10.089
20	0.229	10.319
21	0.213	10.531
22	0.197	10.729
23	0.183	10.911
24	0.170	11.081
25	0.157	11.238
26	0.146	11.384
27	0.135	11.519
28	0.125	11.645
29	0.116	11.761
30	0.108	11.869

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 2% faster than general price levels.

NWC TP 6381

Table 3PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 3%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.968	0.968
2	0.906	1.874
3	0.849	2.723
4	0.795	3.517
5	0.744	4.261
6	0.697	4.958
7	0.652	5.610
8	0.611	6.221
9	0.572	6.793
10	0.536	7.329
11	0.501	7.830
12	0.470	8.300
13	0.440	8.739
14	0.412	9.151
15	0.386	9.536
16	0.361	9.897
17	0.338	10.235
18	0.316	10.552
19	0.296	10.848
20	0.277	11.126
21	0.260	11.386
22	0.243	11.629
23	0.228	11.857
24	0.213	12.070
25	0.200	12.270
26	0.187	12.457
27	0.175	12.632
28	0.164	12.796
29	0.154	12.950
30	0.144	13.093

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 3% faster than general price levels.

NWC TP 6381

Table 4

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 4%

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.972	0.972
2	0.919	1.892
3	0.869	2.761
4	0.822	3.583
5	0.777	4.360
6	0.735	5.095
7	0.695	5.789
8	0.657	6.446
9	0.621	7.067
10	0.587	7.654
11	0.555	8.209
12	0.525	8.734
13	0.496	9.230
14	0.469	9.699
15	0.443	10.142
16	0.419	10.561
17	0.396	10.958
18	0.375	11.333
19	0.354	11.687
20	0.335	12.022
21	0.317	12.339
22	0.299	12.638
23	0.283	12.921
24	0.268	13.189
25	0.253	13.442
26	0.239	13.681
27	0.226	13.908
28	0.214	14.121
29	0.202	14.324
30	0.191	14.515

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 4% faster than general price levels.

NWC TP 6381

Table 5PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 5%*
Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.977	0.977
2	0.933	1.910
3	0.890	2.800
4	0.850	3.650
5	0.811	4.461
6	0.774	5.235
7	0.739	5.974
8	0.706	6.680
9	0.673	7.353
10	0.643	7.996
11	0.614	8.610
12	0.586	9.196
13	0.559	9.755
14	0.534	10.288
15	0.509	10.798
16	0.486	11.284
17	0.464	11.748
18	0.443	12.191
19	0.423	12.614
20	0.404	13.018
21	0.385	13.403
22	0.368	13.771
23	0.351	14.122
24	0.335	14.458
25	0.320	14.777
26	0.305	15.083
27	0.292	15.374
28	0.278	15.653
29	0.266	15.918
30	0.254	16.172

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 5% faster than general price levels.

NWC TP 6381

Table 6PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 6%*
Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.982	0.982
2	0.946	1.928
3	0.912	2.839
4	0.878	3.718
5	0.847	4.564
6	0.816	5.380
7	0.786	6.166
8	0.757	6.923
9	0.730	7.653
10	0.703	8.357
11	0.678	9.035
12	0.653	9.688
13	0.629	10.317
14	0.607	10.924
15	0.584	11.508
16	0.563	12.071
17	0.543	12.614
18	0.523	13.137
19	0.504	13.641
20	0.486	14.127
21	0.468	14.595
22	0.451	15.046
23	0.435	15.480
24	0.419	15.899
25	0.404	16.303
26	0.389	16.692
27	0.375	17.066
28	0.361	17.427
29	0.348	17.775
30	0.335	18.111

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 6% faster than general price levels.

NWC TP 6381

Table 7PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 7%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.986	0.986
2	0.959	1.946
3	0.933	2.879
4	0.908	3.787
5	0.883	4.670
6	0.859	5.529
7	0.836	6.364
8	0.813	7.177
9	0.791	7.968
10	0.769	8.737
11	0.748	9.485
12	0.728	10.212
13	0.708	10.920
14	0.688	11.608
15	0.670	12.278
16	0.651	12.930
17	0.634	13.563
18	0.616	14.180
19	0.600	14.779
20	0.583	15.363
21	0.567	15.930
22	0.552	16.482
23	0.537	17.019
24	0.522	17.541
25	0.508	18.049
26	0.494	18.543
27	0.481	19.023
28	0.467	19.491
29	0.455	19.946
30	0.442	20.388

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 7% faster than general price levels.

NWC TP 6381

Table 8PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 8%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.991	0.991
2	0.973	1.964
3	0.955	2.919
4	0.938	3.857
5	0.921	4.777
6	0.904	5.681
7	0.888	6.569
8	0.871	7.440
9	0.856	8.296
10	0.840	9.136
11	0.825	9.961
12	0.810	10.770
13	0.795	11.565
14	0.781	12.346
15	0.766	13.112
16	0.752	13.865
17	0.739	14.603
18	0.725	15.329
19	0.712	16.041
20	0.699	16.740
21	0.687	17.427
22	0.674	18.101
23	0.662	18.762
24	0.650	19.412
25	0.638	20.050
26	0.626	20.676
27	0.615	21.291
28	0.604	21.895
29	0.593	22.488
30	0.582	23.070

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 8% faster than general price levels.

NWC TP 6381

Table 9PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 9%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	0.995	0.995
2	0.986	1.982
3	0.977	2.959
4	0.969	3.928
5	0.960	4.887
6	0.951	5.839
7	0.942	6.781
8	0.934	7.715
9	0.925	8.640
10	0.917	9.557
11	0.909	10.465
12	0.900	11.366
13	0.892	12.258
14	0.884	13.142
15	0.876	14.018
16	0.868	14.886
17	0.860	15.746
18	0.852	16.598
19	0.845	17.443
20	0.837	18.279
21	0.829	19.109
22	0.822	19.930
23	0.814	20.745
24	0.807	21.551
25	0.800	22.351
26	0.792	23.143
27	0.785	23.928
28	0.778	24.706
29	0.771	25.477
30	0.764	26.241

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 9% faster than general price levels.

NWC TP 6381

Table 10PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 10%*

Discount Rate = 10%

<u>Project Year</u>	<u>Single Amount</u>	<u>Cumulative Uniform Series</u>
1	1.000	1.000
2	1.000	2.000
3	1.000	3.000
4	1.000	4.000
5	1.000	5.000
6	1.000	6.000
7	1.000	7.000
8	1.000	8.000
9	1.000	9.000
10	1.000	10.000
11	1.000	11.000
12	1.000	12.000
13	1.000	13.000
14	1.000	14.000
15	1.000	15.000
16	1.000	16.000
17	1.000	17.000
18	1.000	18.000
19	1.000	19.000
20	1.000	20.000
21	1.000	21.000
22	1.000	22.000
23	1.000	23.000
24	1.000	24.000
25	1.000	25.000
26	1.000	26.000
27	1.000	27.000
28	1.000	28.000
29	1.000	29.000
30	1.000	30.000

* These factors are to be applied to cost elements which are anticipated to escalate at a rate 10% faster than general price levels.

NWC TP 6381

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Mr. SHARKEY. We do have a number of applications we find all the time that are cost effective even after \$20 at peak watt we are paying today. The Navy believes it has, at that price, roughly another 200 to 300 applications that would be cost effective.

In summary, we are doing a lot of renewable energy work. We have a long way to go. We do have cost considerations. We are primarily a consumer when it comes to energy matters, and we try to spend our money as wisely as we can. That means to try to get the most energy for our dollars or save the most energy for our dollars.

Mr. OTTINGER. Do you do the evaluation on a life-cycle cost basis?

Mr. SHARKEY. Yes, we do, sir, and in the renewable area, it is based upon the Mavroules amendment groundrules.

Mr. OTTINGER. Does Mr. Barnes want to testify about what is going on at the Air Force Academy, or do you want to leave it to my questions?

Mr. BARNES. I will leave it to your questions, sir.

Mr. OTTINGER. All right. Thank you, Mr. Sharkey.

[The prepared statement of Mr. Sharkey follows:]

Statement of
Mr. William J. Sharkey, Jr.
Director for Energy and Transportation Policy
Office of the Secretary of Defense

before the

Committee on Science and Technology
House of Representatives .
September 19, 1984

Mr. Chairman, Members of the Committee, thank you for the opportunity to participate in today's panel. As you know, the Department of Defense has had an active coordinated energy program for many years. The objective of our program is to ensure adequate, reliable, secure energy support to our missions at the lowest cost. We view the application of renewable forms of energy wherever appropriate to be a significant contribution to this program .

While I understand today's focus is on photovoltaics, perhaps a brief summary of our efforts in the other renewable technologies would provide a context. The primary emphasis has been on passive and active solar applications. The development of improved design and analysis tools for the incorporation of passive solar techniques has led to the current situation in which most, if not all, new Defense buildings contain some aspects of passive features. The use of such passive features as proper orientation, thermal mass, daylighting and shading are estimated to result in savings of 15 to 25 percent of the annual space heating or cooling requirement. In conjunction with DOE, we are studying the development of analysis tools for more

sophisticated and hybrid passive/active systems and will be applying them wherever cost-effective. We are also working with DOE to develop criteria and analysis tools to help apply passive techniques to existing buildings.

Of all the forms of renewable energy, active solar systems application has received the most attention in the past. We have installed approximately 140 projects of various sizes and types with mixed results. There are approximately 2,500 military family housing units being successfully served by active solar systems, but there have been operational and reliability problems in the early application of the technology. Over the last year we have been performing an evaluation of these systems through the Los Alamos National Laboratory. While the study is not yet completed, we have learned that we have too many one-of-a-kind complex systems. Major problems appear to be improper design, equipment malfunction, and improper operation. The study is leading to the development of an Active Solar Design Handbook which will aid our people in identifying and evaluating the life cycle cost-effectiveness of the optimal solar system for each unique application. The selection will be made from a family of "standard" system configurations which have demonstrated reliability and cost-effectiveness. The handbook will address all aspects of solar system analysis, selection, design, construction and operation and maintenance and should help us take full advantage of this maturing technology.

After some rather disappointing experience with first generation wind machines, our R&D evaluation of this technology is becoming more positive. Reliability testing of second generation commercially available generators indicates that the early research and development is paying off. The Navy, as the lead Service for wind power application, has developed a guide for the evaluation of site specific feasibility of wind system application and conducts physical wind resource tests and evaluations at each potential site. Navy has installed and is testing several installations of the three generic types in the 2 to 12 KW size range and is collecting reliability and performance data to guide future life cycle cost analysis. In the Air Force 2-25 KW machines have been in operation since January 1982 at Reese AFB Texas and an 85 KW turbine at Ascension Island has been producing power since July 1983.

Biomass in the form of refuse-derived fuel and wood chips is considered state-of-the-art and is being applied where the fuel is available and cost-effective. Examples include the refuse plant at the Norfolk Public Works Center burning the equivalent of 50,000 barrels of fuel oil each year and the wood fired boiler being completed at Fort Stewart, Georgia, which will displace 97,000 barrels of fuel oil. Following the direction of our Military Construction Committees, application of this technology in the future will probably be through the use of third party contractors.

.Geothermal energy usage is also a site specific renewable which we are striving to utilize wherever possible. Contracts have been signed for the development of geothermal resources at NWC China Lake, California, and NAS Fallon, Nevada. We expect electrical power sometime in 1985 at China Lake and by 1988 at Fallon. Resource verification evaluations are being made at all promising known geothermal resource sites and we are even evaluating in conjunction with DOE the feasibility of a combination geothermal/ocean thermal plant at Adak, Alaska.

Our most satisfactory experience with renewables has been with photovoltaics. Under the Department of Energy's Federal Photovoltaic Utilization Program (FPUP), the military departments installed 218 systems ranging in size from 10 watts to 56 kilowatts. The FPUP participation gave us not only technical, reliability and maintenance data, but experience in appropriate contracting procedures. The Navy has developed a guide to assist in the application of PV systems and their lead laboratory at the Naval Weapons Center China Lake offers specific assistance to installations interested in systems usage. The Services are sold enough on the technology and cost-effectiveness to be programming systems with their own funds.

For example, the Air Force has installed 48 PV optical scoring systems at six ranges and the Navy is planning over 30 units ranging from 0.10 KW to 25 KW.

The Navy estimates that they have 200 to 300 potential applications in the under 5 kw size range which would be cost effective. Payback on the systems depends of course on the alternative available but the Navy estimates that remote systems are averaging 10 years to payback. The 56 KW Tudor Hill application installed under the cycle IV FPUP effort has a calculated payback less than 2 years. We are experiencing system cost of approximately \$20 per watt and expect to see more cost-effective applications emerge as this price decreases and the cost of alternative power increases. The Services are working with DOE and industry to develop the necessary guides to assist installations in taking advantage of the technology wherever appropriate.

I'd like to comment on two of the specific possible incentive forms proposed in Mr. Fuqua's August 13 letter of invitation and then answer any questions you may have. The extension of the tax credits would affect DoD efforts to use renewable energies only in that it would provide assistance to any third party contractor willing to propose renewable technology in response to any future request for proposals to construct needed power plants for Defense installations.

The direction of the Mavroules amendment has the benefit of helping us keep our eye on the ball. We in DoD have been emphasizing a life cycle cost-effective facilities design

decision process (rather than the traditional lowest first cost) and the use of renewable energy for many years. As you know, it is helpful to have high level Congressional and Administrative interest in such efficiency improvement efforts in periods of limited resources. We are comfortable with and fully supportive of the intent of the legislation, and are striving to fulfill its requirements within our design and construction process.

The amendment recognizes the potential practical constraints of new technology with the direction that renewable energies should be applied whenever possible, reliable and otherwise suited to supplying the energy needs. Clearly unless the application would jeopardize the basic installation mission we are obligated to install renewable systems where cost-effective. Our interpretation of that direction has been that if the system amortizes its first cost over its expected life, using the economic criteria specified, it should be installed. In many instances the directed criteria provides what amounts to over a 35 percent first cost credit to renewable systems when compared with conventional alternatives. We understand the purpose of this incentive but feel uncomfortable that Defense resources are being used to purchase energy which is really not the most life cycle cost-effective. For example, our Energy Conservation Investment Program has historically resulted in 50 to 100 million BTUS of annual energy savings per thousand dollars of investment as compared with 5 to 10 million BTUS of annual energy production from active solar.

However, as I stated earlier we are finding photovoltaics to be a most cost-effective alternative in many locations even using conventional economic analysis criteria. We continue to be enthusiastic about the application of renewable energies particularly photovoltaics to Defense facilities.

I would be happy to go deeper into these or any other issues with you.

Mr. OTTINGER. Mr. Phillips, you may proceed.

STATEMENT OF JAMES R. PHILLIPS, DEPUTY ASSISTANT SECRETARY FOR CAPITAL GOODS AND INTERNATIONAL CONSTRUCTION, U.S. DEPARTMENT OF COMMERCE

Mr. PHILLIPS. Thank you, Mr. Chairman.

Previous testimony has been very gratifying in their references to efforts now in progress by the Department of Energy and the Department of Commerce, particularly the cooperation that has been mentioned. To my mind, this is a visible sign that the cooperation is working.

I will summarize the documented report that I have submitted.

The export development activities of the International Trade Administration encompass three main organizational areas: First is international economic policy which is responsible for country, economic, and commercial information.

Second is the U.S. and foreign commercial service which includes U.S. commercial service district offices located in most States and foreign commercial service offices stationed in embassies throughout the world.

Third is trade development, organized by industry sectors and including international trade specialists assigned to support private sector efforts to develop international markets.

My responsibility, capital goods and international construction, includes an international trade specialist for renewable energy equipment, including photovoltaics, and a major projects officer following overseas renewable energy projects.

ITA's role has evolved from a basis trade promotion to closely coordinated efforts with industry and other Government agencies to assist U.S. renewable energy industry's own efforts in improving their competitive position in the international marketplace.

In the summer of 1982, ITA concluded a series of consultations with representatives of the Export Council for Renewable Energy and Department of Energy officials. This led to an agreement on joint industry/Government action regarding renewable energy export development.

A memorandum of understanding between the Departments of Commerce and Energy was signed in October 1982, formalizing this

agreement. The memorandum of understanding established three basic premises underlying ITA's Renewable Energy Export Development Program.

First, trade development program activities involving photovoltaic and other renewable energy forms would jointly be developed by representatives from ITA, the Energy Department, and the industry.

Second, these activities would be funded by the Department of Energy through a contract to the Commerce Department.

Third, the costs of participation by these firms in specific ITA overseas trade events would be shared by the firms and the U.S. Government.

Over 10 different trade development activities have been carried out by ITA under this memorandum of understanding. These activities include: U.S. renewable energy pavilions at energy trade shows in Hamburg, West Germany, and Singapore; a renewable energy seminar trade mission to the Philippines, Thailand, and Indonesia; electric power trade missions to South and Southeast Asia and the Middle East involving participation by several photovoltaic firms; a catalog exhibition involving photovoltaic and other renewable energy firms in Cypress; a video tape production featuring products and equipment of 18 U.S. renewable energy companies, including 6 photovoltaic firms which were screened in 32 countries around the world.

To date, these and other activities have resulted in projected and actual sales and joint venture and licensing agreements valued by the participating firms at approximately \$14 million. As impressive as this figure is, it is not the most important result of our joint efforts to date.

We have found that overseas awareness of commercial renewable energy equipment and technologies is the key to successful market development efforts for the industry. ITA's efforts, when coordinated or implemented with other Government agencies and agency programs, have increased our own effectiveness. With the support of the Departments of Energy and State, ITA has introduced several new concepts in renewable energy trade promotion.

One example is the reversing of the traditional trade mission approach. ITA, the Department of Energy, the State Department, and the industry's Renewable Energy Institute have brought a total of over 100 foreign government officials from 70 countries around the world to major renewable energy trade events in California in 1983 and again in 1984.

These officials were able to visit company exhibitions, establish a dialogue with company officials, and visit U.S. renewable energy projects and equipment installations.

ITA is currently conducting its first study of the competitiveness of the U.S. renewable energy equipment industry. This report will be augmented by the study mentioned by Mr. Enfield this morning that is being conducted under an ITA/DOE grant.

These Department of Commerce activities coincide with the responsibilities mandated by recent legislation sponsored by Congressman Wyden. These programs will be developed in coordination with the interagency working group established under the provisions of that act and chaired by the Department of Energy.

One of the objectives of the working group is an effort toward improving coordination among a number of U.S. Government agencies for programs and policies which may be of assistance to photovoltaic and other renewable energy firms. A major problem facing these firms is the high risk factor in competing in the commercial credit market for financing of foreign market development and commercial transactions.

In general, we believe there are existing U.S. Government programs to address the risks of export financing facing renewable energy firms. We believe that renewable energy firms should, with our help, become more aware of and utilize these programs more effectively than they have in the past.

Mr. OTTINGER. I am going to have to interrupt you at this point and take the rest of your statement after I go vote. We will be back in about 10 minutes.

[Short recess taken.]

Mr. OTTINGER. The House of Representatives is the real business of this Congress.

I interrupted you, Mr. Phillips.

Mr. PHILLIPS. I only have a couple of seconds left.

The principle of a cooperative approach has been established during the past several years between the Commerce Department and the renewable energy industries to support company market development. We look forward to a new phase of that relationship which holds the promise of expanding the industry/Government partnership to actively include other Government agencies which can affect renewable energy trade and development. From comments this morning, you should realize that we include the ExIm Bank as another Government agency for that effort.

I appreciate the opportunity to present the views of the Commerce Department this afternoon. I would be glad to answer any questions that you might have.

[The prepared statement of Mr. Phillips follows:]

STATEMENT OF
JAMES R. PHILLIPS
DEPUTY ASSISTANT SECRETARY
FOR CAPITAL GOODS AND INTERNATIONAL CONSTRUCTION

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS OF THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, I AM JAMES R. PHILLIPS, DEPUTY ASSISTANT SECRETARY FOR CAPITAL GOODS AND INTERNATIONAL CONSTRUCTION IN THE U.S. DEPARTMENT OF COMMERCE. I APPRECIATE YOUR INVITATION TO TESTIFY BEFORE THE SUBCOMMITTEE ON THE SUBJECT OF RENEWABLE ENERGY EQUIPMENT EXPORTS.

DURING THE PAST SEVERAL YEARS, THE INTERNATIONAL TRADE ADMINISTRATION (ITA) WITHIN THE COMMERCE DEPARTMENT HAS BEEN ACTIVELY SUPPORTING PRIVATE SECTOR EFFORTS TO DEVELOP INTERNATIONAL MARKETS. AS A RESULT OF A RECENT REORGANIZATION, ITA'S STRUCTURE HAS BEEN STRENGTHENED IN ORDER TO ASSIST INDUSTRY EFFORTS IN INTERNATIONAL TRADE.

ITA'S EXPORT DEVELOPMENT ACTIVITIES ENCOMPASS THREE MAIN ORGANIZATIONAL AREAS:

- O THE FIRST AREA, INTERNATIONAL ECONOMIC POLICY, IS ORGANIZED ON A GEOGRAPHIC BASIS AND IS RESPONSIBLE FOR COUNTRY ECONOMIC AND COMMERCIAL INFORMATION.

- O THE SECOND AREA IS THE U.S. AND FOREIGN COMMERCIAL SERVICE, WHICH INCLUDES U.S. COMMERCIAL SERVICE DISTRICT OFFICES LOCATED IN MOST STATES AND FOREIGN COMMERCIAL SERVICE OFFICERS STATIONED IN EMBASSIES AROUND THE WORLD. DISTRICT OFFICE TRADE SPECIALISTS ASSIST U.S. FIRMS WITH SPECIFIC COMMERCE DEPT. EXPORT SERVICES.
- O FOREIGN COMMERCIAL SERVICE OFFICERS AND THEIR FOREIGN NATIONAL STAFFS OBTAIN INFORMATION ON MARKETS AND COMMERCIAL TRADE OPPORTUNITIES FOR U.S. FIRMS, AND PROMOTE U.S. INDUSTRIES OVERSEAS.
- O THE THIRD AREA IS TRADE DEVELOPMENT, WHICH IS ORGANIZED BY INDUSTRY SECTORS. INTERNATIONAL TRADE SPECIALISTS ASSIGNED TO SPECIFIC INDUSTRY SECTORS HAVE DEVELOPED OR ARE DEVELOPING THE EXPERTISE ON INDUSTRIES, THEIR PRODUCTS, EQUIPMENT AND SERVICES, AND THEIR INTERNATIONAL MARKETS.
- O THESE INDUSTRY SPECIALISTS ARE THE COMMERCE DEPARTMENT'S MAJOR LIAISON WITH INDUSTRY REGARDING THEIR COMPETITIVE POSITION IN THE INTERNATIONAL MARKETPLACE.

THE AREA UNDER MY RESPONSIBILITY, CAPITAL GOODS AND INTERNATIONAL CONSTRUCTION, INCLUDES AN INTERNATIONAL TRADE SPECIALIST FOR RENEWABLE ENERGY EQUIPMENT AND A MAJOR PROJECTS OFFICER FOLLOWING OVERSEAS RENEWABLE ENERGY PROJECTS.

DURING THE PAST FOUR YEARS, ITA HAS PURSUED AN ACTIVE ROLE IN PROMOTING COMMERCIAL U.S. RENEWABLE ENERGY TECHNOLOGIES OVERSEAS AND IN SUPPORTING RENEWABLE ENERGY INDUSTRY EXPORT DEVELOPMENT EFFORTS IN FOREIGN MARKETS.

ITA'S ROLE HAS EVOLVED FROM BASIC TRADE PROMOTION TO CLOSELY COORDINATED EFFORTS WITH INDUSTRY REPRESENTATIVES AND OTHER GOVERNMENT AGENCIES TO ASSIST THE U.S. RENEWABLE ENERGY INDUSTRY'S OWN EFFORTS TO IMPROVED ITS COMPETITIVE POSITION IN THE INTERNATIONAL MARKETPLACE.

IN THE FALL OF 1981, FOLLOWING CONSULTATION WITH INDUSTRY OFFICIALS, ITA DEVELOPED AN EXPORT DEVELOPMENT PLAN FOR THE RENEWABLE ENERGY EQUIPMENT INDUSTRY SECTOR. THE PLAN CALLED FOR A SERIES OF OVERSEAS TRADE EVENTS INVOLVING U.S. RENEWABLE ENERGY FIRMS AND A GREATER FOCUS ON U.S. GOVERNMENT POLICIES AFFECTING THESE FIRMS. EARLY IN 1982 A UNIFIED SECTOR-WIDE U.S. EXPORT COUNCIL FOR RENEWABLE ENERGY (ECRE) WAS FORMED, COMPOSED OF INDUSTRY TRADE GROUPS AND ASSOCIATIONS. SHORTLY THEREAFTER, THE ITA TRADE PROMOTION PROGRAM INVOLVING RENEWABLE ENERGY EQUIPMENT WAS INITIATED.

DURING THE SUMMER OF 1982, ITA CONCLUDED A SERIES OF CONSULTATIONS WITH ECRE REPRESENTATIVES AND DEPARTMENT OF ENERGY OFFICIALS. THIS LEAD TO AN AGREEMENT ON JOINT INDUSTRY/GOVERNMENT ACTION REGARDING RENEWABLE ENERGY EXPORT DEVELOPMENT.

A MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPARTMENTS OF COMMERCE AND ENERGY WAS SIGNED IN OCTOBER 1982 FORMALIZING THIS AGREEMENT.

THE MEMORANDUM OF UNDERSTANDING ESTABLISHED THREE BASIC PREMISES UNDERLYING ITA'S EXPORT DEVELOPMENT PROGRAM:

1. TRADE DEVELOPMENT PROGRAM ACTIVITIES INVOLVING THE RENEWABLE ENERGY INDUSTRY WOULD BE JOINTLY DEVELOPED BY REPRESENTATIVES FROM ITA, THE ENERGY DEPARTMENT AND INDUSTRY.
2. THESE ACTIVITIES, EXCLUSIVE OF ITA'S INDIRECT ADMINISTRATIVE COSTS, WOULD BE FUNDED BY THE DEPARTMENT OF ENERGY THROUGH A CONTRACT TO THE COMMERCE DEPARTMENT.
3. IN RECOGNITION OF THE LIMITED FUNDS AVAILABLE TO U.S. RENEWABLE ENERGY FIRMS FOR INTERNATIONAL MARKET DEVELOPMENT, THE COSTS OF PARTICIPATION BY THESE FIRMS IN SPECIFIC ITA OVERSEAS TRADE EVENTS WOULD BE SHARED BY THESE FIRMS AND THE U.S. GOVERNMENT.

OVER 10 DIFFERENT TRADE DEVELOPMENT ACTIVITIES HAVE BEEN DEVELOPED AND CARRIED OUT BY ITA UNDER THIS MEMORANDUM OF UNDERSTANDING. THESE ACTIVITIES INCLUDE:

- O U.S. RENEWABLE ENERGY PAVILIONS AT ENERGY TRADE SHOWS IN HAMBURG, WEST GERMANY AND SINGAPORE INVOLVING OVER 30 COMPANIES.
- O A RENEWABLE ENERGY SEMINAR TRADE MISSION TO THE PHILIPPINES, THAILAND AND INDONESIA INVOLVING 7 U.S. FIRMS.
- O ELECTRIC POWER TRADE MISSIONS TO SOUTH AND SOUTHEAST ASIA AND THE MIDDLE EAST INVOLVING PARTICIPATION BY SEVERAL RENEWABLE ENERGY FIRMS.
- O A CATALOG EXHIBITION INVOLVING 60 U.S. RENEWABLE ENERGY FIRMS AT AN INTERNATIONAL TRADE SHOW IN CYPRUS.
- O A VIDEO TAPE PRODUCTION FEATURING PRODUCTS AND EQUIPMENT OF 18 U.S. RENEWABLE ENERGY COMPANIES, AND SCREENED IN 32 COUNTRIES AROUND THE WORLD.
- O VISITS BY FOREIGN GOVERNMENT ENERGY OFFICIALS TO A MAJOR DOMESTIC RENEWABLE ENERGY TRADE EVENT IN CALIFORNIA INVOLVING ALMOST 300 FIRMS.

- O A STUDY CONDUCTED BY THE EXPORT COUNCIL FOR RENEWABLE ENERGY OF THE EFFECT OF PUBLIC POLICY ON THE RENEWABLE ENERGY INDUSTRIES IN THE U.S. AND 5 COMPETITOR COUNTRIES.

TO DATE, THESE AND OTHER ACTIVITIES, WHICH HAVE COST APPROXIMATELY \$400,000 FROM ITA/DOE PROJECT FUNDS, HAVE RESULTED IN PROJECTED AND ACTUAL SALES, JOINT VENTURE AND LICENSING AGREEMENTS VALUED BY PARTICIPATING FIRMS AT APPROXIMATELY \$14 MILLION.

AS IMPRESSIVE AS THIS FIGURE IS, IT IS NOT THE MOST IMPORTANT RESULT OF OUR JOINT EFFORTS WITH INDUSTRY.

WE HAVE FOUND THAT OVERSEAS AWARENESS OF COMMERCIAL RENEWABLE ENERGY EQUIPMENT AND TECHNOLOGIES IS THE KEY TO SUCCESSFUL MARKET DEVELOPMENT EFFORTS FOR THIS INDUSTRY. INCREASING THE AWARENESS OF BOTH GOVERNMENT OFFICIALS AND THE BUSINESS COMMUNITY IN DEVELOPING COUNTRIES OF THE EFFICIENT AND COST-EFFECTIVE END-USE OF THIS EQUIPMENT HAS LED TO A SIGNIFICANT INCREASE IN INTEREST AND ACTIVITY INVOLVING COMMERCIAL RENEWABLE ENERGY DEVELOPMENT.

WE HAVE ALSO FOUND THAT AS THE QUANTITY AND QUALITY OF INDUSTRY/GOVERNMENT TRADE PROMOTION ACTIVITIES INCREASE, THE INTEREST OF RENEWABLE FIRMS IN OVERSEAS MARKETS HAS HEIGHTENED.

IN THE PAST, THE RENEWABLE ENERGY INDUSTRY SECTOR HAS GENERALLY BEEN MORE ACTIVE IN OVERSEAS MARKETS THAN THE AVERAGE OF ALL U.S. INDUSTRY SECTORS. THIS IS PRIMARILY DUE TO THE REALIZATION THAT COUNTRIES WITHOUT ESTABLISHED ENERGY NETWORKS OFFER THE BEST LONG-TERM MARKETS. HOWEVER, THE MAJORITY OF RENEWABLE ENERGY FIRMS ARE SMALL TO MEDIUM-SIZE FIRMS WITH LIMITED WORKING CAPITAL, AND THUS, IN SOME RESPECTS, RESEMBLE MANY FIRMS IN OTHER INDUSTRY SECTORS.

FAMILIARITY WITH LOCAL U.S. MARKETS, LOCAL FINANCING NETWORKS, CONCENTRATION ON MEETING SHORT-TERM DEMAND, AND LIMITED FINANCIAL AND STAFF RESOURCES HAVE LED MANY RENEWABLE ENERGY FIRMS TO POSTPONE SERIOUS CONSIDERATION OF INTERNATIONAL MARKET DEVELOPMENT.

BY INCREASING TRADE PROMOTION OPTIONS AND OFFERING TO SHARE THE COST OF INITIAL MARKET DEVELOPMENT, WE HAVE PROVIDED THE INCENTIVE THAT MANY U.S. FIRMS NEEDED TO EXPLORE OVERSEAS TRADE OPPORTUNITIES. AS A MARK OF SUCCESS, OVER 60% OF THE COMPANIES PARTICIPATING IN OUR RECENT RENEWABLE ENERGY TRADE EVENTS HAVE BEEN NEW-TO-EXPORT OR NEW-TO-MARKET FIRMS.

OUR JOINT EFFORTS WITH INDUSTRY IN RENEWABLE ENERGY TRADE DEVELOPMENT HAS BROUGHT INTO FOCUS A NUMBER OF OTHER IMPORTANT POINTS. ITA'S EFFORTS, WHEN COORDINATED OR IMPLEMENTED WITH OTHER GOVERNMENT AGENCIES AND AGENCY PROGRAMS, HAS INCREASED OUR OWN EFFECTIVENESS IN SUPPORTING RENEWABLE ENERGY COMPANY MARKETING OBJECTIVES.

DIFFERING COUNTRY ECONOMIC AND COMMERCIAL CONDITIONS AND TRADE DEVELOPMENT POLICIES REQUIRE INNOVATIVE TRADE PROMOTION TECHNIQUES AND A CERTAIN DEGREE OF PROGRAM FLEXIBILITY. WITH THE SUPPORT OF THE DEPARTMENTS OF ENERGY AND STATE, ITA HAS INTRODUCED SEVERAL NEW CONCEPTS IN RENEWABLE ENERGY TRADE PROMOTION.

FOR EXAMPLE, A SYMPOSIUM SPONSORED BY THE GOVERNMENT OF SPAIN ON WIND FARM DEVELOPMENT IN THE CANARY ISLANDS RESULTED IN OUR ORGANIZING AN OFFICIAL INDUSTRY DELEGATION TO GO TO THIS CONFERENCE. THE DELEGATION WAS LED BY THE AMERICAN WIND ENERGY ASSOCIATION AND COMPOSED OF SIX WIND ENERGY COMPANIES.

A SECOND INNOVATIVE TRADE PROMOTION TECHNIQUE HAS PREVIOUSLY BEEN MENTIONED. BY REVERSING THE TRADITIONAL TRADE MISSION APPROACH (I.E., U.S. FIRMS MEETING WITH FOREIGN GOVERNMENT OFFICIALS IN THEIR COUNTRY), ITA, THE DEPARTMENT OF ENERGY, THE STATE DEPARTMENT, AND THE INDUSTRY'S RENEWABLE ENERGY INSTITUTE HAVE BROUGHT A TOTAL OF OVER 100 HIGH-LEVEL FOREIGN GOVERNMENT ENERGY OFFICIALS FROM ALMOST 70 COUNTRIES AROUND THE WORLD TO A MAJOR RENEWABLE ENERGY TRADE EVENT IN CALIFORNIA, BOTH IN 1983 AND 1984.

THESE OFFICIALS WERE ABLE TO VIEW EXHIBITIONS BY APPROXIMATELY 300 FIRMS, ESTABLISH A DIALOGUE WITH OFFICIALS FROM MANY OF THESE FIRMS, AND VISIT RENEWABLE ENERGY PROJECTS AND EQUIPMENT INSTALLATIONS IN CALIFORNIA.

PERHAPS THE MOST IMPORTANT POINT WHICH HAS BEEN HIGHLIGHTED BY OUR JOINT INDUSTRY/GOVERNMENT PROGRAM IS THAT TRADE PROMOTION ACTIVITIES DO NOT OPERATE IN A VACUUM. THE ABILITY OF THE U.S. RENEWABLE ENERGY INDUSTRY SECTOR TO COMPETE EFFECTIVELY IN INTERNATIONAL MARKETS MUST BE ASSESSED AND UNDERSTOOD IN ORDER TO CREATE SUCCESSFUL TRADE OPPORTUNITIES.

THE INTERNATIONAL MARKETPLACE AT TIMES RESEMBLES AN UNLEVEL PLAYING FIELD. COMPETITOR NATION FIRMS ARE OFTEN ABLE TO ACCESS POLICIES AND PROGRAMS WHICH WE DO NOT BELIEVE ARE COMPATABLE WITH OUR FREE ENTERPRISE SYSTEM. SUCH TRADING PRACTICES CAN OFTEN RESULT IN SHORT-TERM ADVANTAGES FOR THESE FIRMS.

THE ADMINISTRATION BELIEVES, HOWEVER, THAT BI-LATERAL AND MULTI-LATERAL EFFORTS BY THE U.S. GOVERNMENT TO ESTABLISH FREE AND FAIR WORLD TRADE, COUPLED WITH SUPPORT FOR INDUSTRY'S OWN EFFORTS TO INCREASE ITS COMPETITIVENESS IS THE MOST EFFECTIVE POLICY TO INCREASE U.S. INDUSTRY EXPORTS.

THE FIRST STEP IN THIS PROCESS IS TO ASSESS THE U.S. INDUSTRIES INTERNATIONAL COMPETITIVENESS. ITA IS CURRENTLY CONDUCTING ITS FIRST STUDY ON THE COMPETITIVENESS OF THE RENEWABLE ENERGY EQUIPMENT INDUSTRY. THIS STUDY WILL BE AUGMENTED BY A STUDY OF THE EFFECT OF PUBLIC POLICY ON RENEWABLE ENERGY EQUIPMENT INDUSTRIES IN THE U.S. AND FIVE MAJOR COMPETITOR NATIONS, WHICH IS BEING CONDUCTED BY THE U.S. EXPORT COUNCIL FOR RENEWABLE ENERGY UNDER AN ITA GRANT UTILIZING COMMERCE/ENERGY DEPARTMENT PROJECT FUNDS.

THE RESULTS OF BOTH STUDIES WILL BE MADE AVAILABLE TO THE APPROPRIATE CONGRESSIONAL COMMITTEES, U.S. GOVERNMENT AGENCIES AND RENEWABLE ENERGY INDUSTRY FIRMS. ONCE THE FACTORS WHICH INFLUENCE THIS INDUSTRY'S COMPETITIVE POSITION IN INTERNATIONAL MARKETS BECOME APPARENT, INDUSTRY AND GOVERNMENT CAN JOIN IN A COOPERATIVE APPROACH TO RENEWABLE ENERGY INTERNATIONAL MARKET DEVELOPMENT.

PLEASE NOTE THAT THE COMMERCE DEPARTMENT'S OWN INTERNAL TRADE DEVELOPMENT POLICIES COINCIDE WITH THE RESPONSIBILITIES MANDATED BY RECENT LEGISLATION WHICH WAS ENACTED BY CONGRESS AND SIGNED BY THE PRESIDENT. THE "RENEWABLE ENERGY INDUSTRY EXPORT DEVELOPMENT ACT OF 1983, KNOWN AS THE WYDEN ACT," INSTRUCTS THE COMMERCE DEPARTMENT TO CONDUCT A COMPETITIVE ASSESSMENT OF THE RENEWABLE ENERGY INDUSTRIES.

BASED ON THE RESULTS OF THIS ASSESSMENT, THE COMMERCE DEPARTMENT IS TO FORMULATE A PROGRAM TO ASSIST THE INDUSTRY'S EFFORTS IN IMPROVING ITS COMPETITIVENESS AND IN DEVELOPING EXPORT MARKETS.

THIS PROGRAM WOULD BE DEVELOPED IN COORDINATION WITH AN INTERAGENCY WORKING GROUP, CHAIRED BY THE DEPARTMENT OF ENERGY, WHICH IS TO BE ESTABLISHED UNDER THE PROVISIONS OF THE WYDEN ACT. WE ARE FULLY SUPPORTIVE, MR. CHAIRMAN, OF THE INTENT OF THIS LEGISLATION, AND WILL BE COOPERATING WITH THE DEPARTMENT OF ENERGY AND OTHER U.S. GOVERNMENT AGENCIES TO ENSURE THAT ITS OBJECTIVES ARE MET.

I WOULD LIKE TO ADD THAT ONE OF THESE OBJECTIVES, SOUGHT BY INDUSTRY REPRESENTATIVES, U.S. RENEWABLE ENERGY FIRMS, CONGRESS AND THE ADMINISTRATION, IS AN EFFORT TOWARD BETTER COORDINATION AMONG A NUMBER OF U.S. GOVERNMENT AGENCIES OF POLICIES AND PROGRAMS WHICH MAY BE OF ASSISTANCE TO FIRMS WITHIN THIS INDUSTRY.

THE FIRST MEETING OF THE INTERAGENCY WORKING GROUP WILL BE HELD WITHIN THE NEXT SEVERAL WEEKS. AS THE WORKING GROUP'S AGENDA FORMS, WE EXPECT IT TO INCLUDE A REVIEW OF BOTH THE COMPETITIVENESS OF THE RENEWABLE ENERGY EQUIPMENT INDUSTRY SECTOR AND THE PARTICULAR PROBLEMS THIS YOUNG INDUSTRY SECTOR FACES IN ITS MAJOR FOREIGN MARKETS, I.E., DEVELOPING COUNTRIES.

THE WORKING RELATIONSHIP THAT THE COMMERCE DEPARTMENT HAS ESTABLISHED WITH MANY RENEWABLE ENERGY FIRMS AND INDUSTRY REPRESENTATIVES, COUPLED WITH THE EXPERIENCE GAINED DURING THE PAST SEVERAL YEARS OF RENEWABLE ENERGY TRADE EVENTS AND COMPETITIVE ASSESSMENT RESEARCH, HAS PROVIDED US WITH A CLEARER PICTURE OF OBSTACLES CONFRONTING THE RENEWABLE ENERGY INDUSTRIES IN DEVELOPING COUNTRY MARKETS. FORMOST AMONG THESE IS THE OVERALL PROBLEM OF FINANCING MARKET DEVELOPMENT AND COMMERCIAL ACTIVITIES IN THESE COUNTRY MARKETS.

RENEWABLE ENERGY FIRMS FACE SEVERAL NEGATIVES RELATING TO RISK WHEN THEY SEEK COMMERCIAL CREDIT FOR SUCH ACTIVITIES. THE COMMERCIAL EQUIPMENT AND TECHNOLOGIES WHICH THEY ARE MARKETING ARE RELATIVELY YOUNG, LESS THAN 13 YEARS OLD, WITH A LIMITED OPERATING TRACK RECORD AND A HIGH, UPFRONT CAPITAL COST. MANY COMPANIES ARE YOUNG WITH LIMITED EXPERIENCE IN INTERNATIONAL COMMERCE. THEY ARE AT A DISADVANTAGE IN COMPETITION FOR FINANCING CAPITAL WITH FIRMS IN OTHER INDUSTRIES WITH AN ESTABLISHED SUCCESS RATE IN FOREIGN COMMERCIAL TRANSACTIONS.

FINALLY, THE LARGEST POTENTIAL MARKETS FOR RENEWABLE ENERGY EQUIPMENT AND SERVICES ARE THOSE DEVELOPING COUNTRIES WHICH RELY ON IMPORTED CONVENTIONAL FUELS. THEY HAVE LARGE SEGEMENTS OF THEIR POPULATION RESIDING IN REMOTE AREAS WITHOUT ACCESS TO CONVENTIONAL ENERGY SOURCES OR ESTABLISHED POWER NETWORKS.

SUCH COUNTRIES TEND TO HAVE HARD CURRENCY SHORTAGES, IMPORT RESTRICTIONS, LIMITED IN-COUNTRY CAPITAL FORMATION, AND MINIMAL PRACTICAL EXPERIENCE WITH OR KNOWLEDGE OF RENEWABLE ENERGY PRODUCTS AND SYSTEMS.

IN A COMPETITIVE COMMERCIAL CREDIT MARKET, THESE COUNTRIES ARE SELDOM GIVEN HIGH PRIORITY.

THE ADMINISTRATION IS AWARE OF THIS SITUATION AND BELIEVES THAT POLICIES IMPLEMENTED DURING THE PAST SEVERAL YEARS WILL EFFECTIVELY ADDRESS THIS OBSTACLE TO MARKETING NEW TECHNOLOGIES IN THE DEVELOPING WORLD. THE STRONG GROWTH OF THE U.S. ECONOMY DURING THE PAST 24 MONTHS, HAS LED TO A PREDICTED INCREASE IN WORLD TRADE. EXPORTS BY MOST DEVELOPING COUNTRIES DURING 1984 APPEAR ONCE AGAIN TO BE ON A GROWTH CURVE. WITH THE EXPECTATION THAT U.S., OECD AND WORLD ECONOMIC GROWTH WILL CONTINUE, THESE DEVELOPING COUNTRIES CAN EXPECT TO EARN THE NEEDED HARD CURRENCY TO PURCHASE CAPITAL EQUIPMENT FOR ECONOMIC DEVELOPMENT.

SINCE 1981, MR. CHAIRMAN, THE ADMINISTRATION HAS STRONGLY URGED THE MULTI-LATERAL DEVELOPMENT COMMUNITY TO INCREASE ITS FOCUS ON THE DYNAMICS AND ROLE OF THE PRIVATE SECTOR IN DEVELOPING RENEWABLE ENERGY RESOURCES. OUR POSITION THEN AS NOW IS THAT WITH PROPER SUPPORT FROM THE PUBLIC SECTOR, THE PRIVATE SECTOR CAN EFFECTIVELY COMMERCIALIZE RENEWABLE ENERGY TECHNOLOGIES (AS HAS HISTORICALLY BEEN THE CASE WITH MORE CONVENTIONAL ENERGY TECHNOLOGIES). THE SUCCESS OF THE U.S. RENEWABLE ENERGY INDUSTRY DURING THE PAST SEVERAL YEARS IS EVIDENCE OF THE VITALITY AND RESOURCEFULNESS OF THE PRIVATE SECTOR.

WE BELIEVE THAT THE KEY TO THE DEVELOPMENT OF RENEWABLE ENERGY EQUIPMENT MARKETS IN DEVELOPING COUNTRIES AND CONSEQUENT RENEWABLE ENERGY RESOURCE DEVELOPMENT SIMILARLY LIES WITH THE STRENGTHENING OF IN-COUNTRY PRIVATE SECTOR IN THESE COUNTRIES. WE NOTE WITH SATISFACTION THAT THE INTERNATIONAL FINANCE CORPORATION (IFC) OF THE WORLD BANK GROUP HAS RECEIVED SUFFICIENT FUNDING FOR INCREASED PROGRAM ACTIVITY TO ASSIST THE PRIVATE SECTOR IN DEVELOPING COUNTRIES, AND THAT THE IFC HAS RECENTLY TURNED ITS ATTENTION TO ENCOURAGING PRIVATE SECTOR INITIATIVES IN ENERGY DEVELOPMENT. I MIGHT ADD, MR. CHAIRMAN, THAT THIS COINCIDES WITH A DEFINITE TREND WHICH HAS DEVELOPED IN OVERSEAS EQUIPMENT TRADE WITH DEVELOPING COUNTRIES DURING THE 1980'S, I.E., THE INCREASED IMPORTANCE OF JOINT VENTURES AND LICENSING AGREEMENTS IN DEVELOPING COUNTRY MARKETS.

IN THE BUSINESS WORLD, TAKING ADVANTAGE OF THE EXPERIENCE AND ABILITIES OF AN IN-COUNTRY PRIVATE SECTOR FIRM MAKES A GREAT DEAL OF SENSE. FROM THE POINT OF VIEW OF DEVELOPING COUNTRIES, THE BENEFITS OF COMMERCIAL PRIVATE SECTOR COOPERATION AND FOREIGN INVESTMENT CAN SPUR THE GROWTH OF NEW BUSINESS AND EMPLOYMENT OPPORTUNITIES. SUCH COMMERCIAL COOPERATION CAN INCLUDE A RANGE OF ACTIVITIES, INCLUDING IMPORTATION OF SYSTEMS AND PRODUCTS TO GAIN MARKET FAMILIARITY WITH THE PARTICULAR RENEWABLE ENERGY EQUIPMENT; ASSEMBLY AND/OR MANUFACTURE, WHEN FEASIBLE, OF SYSTEM COMPONENTS; AND SERVICE CONTRACTS FOR PROJECT DESIGN, TRAINING IN SYSTEMS INSTALLATION, EQUIPMENT OPERATION AND MAINTENANCE, AND GENERAL CONSULTATION LEADING TO JOINT REGIONAL MARKETING PLANS.

RENEWABLE ENERGY INDUSTRY FIRMS AND REPRESENTATIVES HAVE BECOME INCREASINGLY AWARE OF THIS TREND, AS WELL AS THE IMPORTANCE OF INTERNATIONAL DEVELOPMENT INSTITUTION SUPPORT FOR IN-COUNTRY PRIVATE SECTORS. WE AGREE WITH INDUSTRY REPRESENTATIVES THAT ANY SUCH SUPPORT FOR ENERGY DEVELOPMENT SHOULD INCLUDE RENEWABLE ENERGY RESOURCES. THIS POINT WILL BECOME PART OF THE INTERAGENCY WORKING GROUP'S AGENDA.

IN GENERAL, MR. CHAIRMAN, THE ADMINISTRATION BELIEVES THAT EXISTING U.S. GOVERNMENT PROGRAMS TO REDUCE RISKS OF EXPORT FINANCING, SUCH AS THE EXPORT-IMPORT BANK LOAN GUARANTY PROGRAM AND THE OVERSEAS PRIVATE INVESTMENT CORPORATION'S INVESTMENT INSURANCE PROGRAM, ARE SUFFICIENT TO RESOLVE PROBLEMS FACING RENEWABLE ENERGY FIRMS. WE BELIEVE THAT RENEWABLE ENERGY FIRMS SHOULD BECOME MORE AWARE OF AND UTILIZE THESE PROGRAMS A BIT MORE EFFECTIVELY THAN THEY HAVE IN THE PAST.

THESE PROPOSALS, WHICH WOULD BE TIED TO THE IFC'S ENERGY DEVELOPMENT PROGRAM, HAVE A NUMBER OF INTERESTING ELEMENTS AND DESERVE CONSIDERATION BY THE INTERAGENCY WORKING GROUP AND APPROPRIATE U.S. GOVERNMENT AGENCIES.

A NUMBER OF OTHER INDUSTRY PROPOSALS TO REDUCE THE RISK ASSOCIATED WITH RENEWABLE ENERGY TECHNOLOGIES COMBINE THE U.S. GOVERNMENT'S NEED TO DIVERSIFY SOURCES OF ENERGY FOR ITS OWN CONSUMPTION WITH INDUSTRY'S NEED FOR DEMONSTRATION OF COMMERCIALLY VIABLE, OPERATING SYSTEMS. ESSENTIALLY, THESE PROPOSALS CALL FOR THE PURCHASE AND INSTALLATION OF VARIOUS COMMERCIAL RENEWABLE ENERGY SYSTEMS AND EQUIPMENT IN DEPARTMENT OF DEFENSE FACILITIES AND BASES AROUND THE WORLD AND IN THE U.S. TRUST TERRITORIES. THE PURPOSE WOULD BE TO:

- O ASSIST THE DEFENSE DEPARTMENT IN ITS EFFORTS TO DECREASE ITS RELIANCE ON IMPORTED FOSSIL FUELS AND THUS IMPROVE ITS ENERGY SECURITY WHILE CUTTING ENERGY COSTS;
- O ASSIST THE TRUST TERRITORIES IN DEVELOPING INDIGINEOUS SOURCES OF ENERGY WHILE DECREASING THE ANNUAL COSTS BORNE BY THE DEPARTMENT OF INTERIOR FOR PURCHASE BY THE TRUST TERRITORIES OF IMPORTED FOSSIL FUELS; AND
- O ENABLE U.S. RENEWABLE ENERGY FIRMS TO BRING FOREIGN GOVERNMENT ENERGY OFFICIALS AND BUSINESS REPRESENTATIVES TO THESE AREAS TO VIEW COST-EFFECTIVE OPERATING SYSTEMS, AND TO DEMONSTRATE A TRACK RECORD FOR THESE SYSTEMS.

WE BELIEVE THAT THESE PROPOSALS COULD SIMULTANEOUSLY SERVE THE INTERESTS OF THE GOVERNMENT, THE TAXPAYERS AND INDUSTRY, AND SHOULD ALSO BE CONSIDERED BY THE INTERAGENCY WORKING GROUP AND APPROPRIATE GOVERNMENT AGENCIES.

THE PAST SEVERAL YEARS, MR. CHAIRMAN, HAS SEEN A REMARKABLE EVOLUTION IN RENEWABLE ENERGY INDUSTRY/GOVERNMENT RELATIONS. THE PRINCIPLE OF A COOPERATIVE APPROACH HAS BEEN ESTABLISHED BY THE DEPARTMENT OF COMMERCE AND THE RENEWABLE ENERGY INDUSTRY TO SUPPORT PRIVATE SECTOR EXPORTING EFFORTS--A PARTNERSHIP BETWEEN INDUSTRY AND GOVERNMENT TO PROMOTE U.S. COMMERCIAL INTERESTS.

WE ARE ABOUT TO EMBARK ON A NEW PHASE OF THAT RELATIONSHIP WHICH HOLDS THE PROMISE OF EXPANDING THAT PARTNERSHIP TO ACTIVELY INCLUDE A RANGE OF GOVERNMENT AGENCIES WHICH AFFECT RENEWABLE ENERGY TRADE AND DEVELOPMENT. PARALLEL TO THIS MAY BE THE DEVELOPMENT OF MUTUALLY BENEFICIAL PARTNERSHIPS BETWEEN U.S. AND DEVELOPING COUNTRY FIRMS TO COMMERCIALLY DEVELOP IN-COUNTRY RENEWABLE ENERGY RESOURCES.

WE LOOK FORWARD TO CONTINUED COOPERATION WITH THIS SUBCOMMITTEE AND OTHER CONGRESSIONAL COMMITTEES DURING THIS NEXT PHASE.

THANK YOU FOR THE OPPORTUNITY TO PRESENT THE VIEWS OF THE COMMERCE DEPARTMENT AT THIS HEARING. I AM NOW AVAILABLE FOR ANY QUESTIONS WHICH YOU MAY HAVE.

Mr. OTTINGER. All right.

I thank all of you.

I would like to acknowledge your kind remarks, Mr. Sharkey, and return them and express appreciation for the cooperation the Defense Department has given in exploring the uses of renewable in general, and photovoltaics in specific, and it is largely due to your efforts.

Mr. SHARKEY. Thank you, sir.

Mr. OTTINGER. I wonder if you would like to comment on the suggestions that Mr. Sklar made, both of which seemed to me to have some validity. One is to give some greater assistance to assure that procurement officers get briefed on the actual potential uses of photovoltaics. Clearly, Mr. Sklar's resources are not adequate to do that or the Solar Energy Industries Association by itself.

Is there some way the Defense Department could get together regional meetings of its local procurement officers?

Mr. SHARKEY. I think that is possible. The fact of life is, as he stated he was told, we do run a very decentralized system. There is some thought that the farther away you are from Washington when anything gets done, the likelihood of its getting done well improves. We kind of believe that. Base commanders are given an enormous amount of responsibility for contracting and for spending money on things to equip their own bases.

However, because of that, the military departments do find, for their internal coordination purposes, it is necessary, periodically, on an annual basis or thereabouts, to get, for example, their engineering officers together and have a service wide meeting or a regional meeting. Those kinds of things do occur in the Department of Defense.

What we will do is take a look at how we could perhaps piggy-back Mr. Sklar's presentation onto those kinds of events, so at least he will not be traipsing all over the country. He will have a few events to attend.

Mr. OTTINGER. That, I think, would be very helpful. This information clearly is a key factor in your local procurement officers making sound decisions.

How much has the Defense Department actually done in the last few years in terms of procurement of photovoltaics? Do you have the figures with you?

Mr. SHARKEY. I have figures on the FPUP program itself which was 218 systems. In preparing for this particular hearing, I found it difficult to get any kind of comprehensive figure on what we

have bought ourselves because of what we were just talking about earlier, the decentralized nature of the thing. Many of the photovoltaic things that we have were cost effective. Many paid back in between 2 and 10 years, and many were bought locally with operations and maintenance money so that they never did become part of a budget that we saw at our level. So, I am afraid I don't have a good figure for you at this point.

Mr. OTTINGER. Could you supply that for us?

Mr. SHARKEY. I will try to, yes, sir.

[Material to be supplied follows:]

IN-HOUSE PHOTOVOLTAIC PURCHASES

Answer. The Navy's photovoltaic lead laboratory at China Lake is aware of at least 30 small photovoltaic systems such as remote site magazing lighting and remote communications power which have been installed through local activity purchase authority. There is no requirement for a central data base of this information since it is becoming thought of as off-the-shelf equipment. It is estimated that a similar number of such equipments, i.e., under 5 KW, are in service in the Army and Air Force with no efficient method of gathering meaningful statistics.

Mr. OTTINGER. The price of photovoltaic systems is plummeting each year. Do you do advance preparation knowing that that is going to happen so that you would know, for example, that if the price came down by 50 percent next year, what additional uses might be cost effective and you could alert your people?

Mr. SHARKEY. I would have to supply that for the record. I am not aware of it. It may be being done out at the Navy's laboratory at China Lake.

Mr. OTTINGER. I think that would be very useful. You have here technology that every year has been high slicing its cost, and each time the costs are sliced, clearly, a new series of applications becomes cost effective. It would seem to me to be well to do some advance planning for that so that you could make quick use of new developments.

[Material to be supplied follows:]

PHOTOVOLTAIC MARKET POTENTIAL

Answer. The program manager of the Navy's lead laboratory for photovoltaics, China Lake, has recently conducted a "market analysis" for potential photovoltaic application. It is estimated that there are approximately 5,000 cost-effective, small (under 5 KW), remote site applications at today's average purchase cost of \$20 per installed watt. It has also been estimated that, if the cost was reduced 50 percent to the 1990 DOE target price of \$10 per watt, the Navy would have approximately 3,000 applications of medium-sized systems (25 to 50 KW) and 10,000 small remote applications. The Navy has developed a list of potential applications and is in a position to apply photovoltaics if (or when) the price falls.

Mr. OTTINGER. What about for centralized procurements? Do you have information on—what would be the potential for accumulating the requests of the various local procurement officers and making procurements centrally?

Mr. SHARKEY. That is an interesting concept that we have not explored. If, instead of lots of small systems, we were to make one big buy, we could perhaps even drive the price lower. Administratively, whether we can do that, whether we have that visibility, I don't know, but we will take a good hard look at that and see if we can work something out.

Mr. OTTINGER. Have you had problems with life cycle costing?

Mr. SHARKEY. No, sir.

Mr. OTTINGER. All right.

Last year, you testified before the Armed Services Committee that you are pushing third party financing to attract private capital to develop energy generating facilities without awaiting the uncertain and lengthy military construction budget process. What has been the success of that effort?

Mr. SHARKEY. It is a new program, so there are growing pains. In May of this year, we did publish a policy memo, "Defense Energy Policy Memo, Third Party Funding of Facilities Energy Systems," which was developed over a period of a number of months working with the military services to make sure they understood it and agreed with it. The services, since then, have developed their own service implementation of this.

There are a number of third party contracts in the mill being worked. As has been alluded to in the case of the Air Force Academy, not necessarily going all that smoothly. However, we have, in fact, done a couple or three. The Navy is ahead of anybody else on this. They have several successful third party contracts right now that have been completely executed.

Mr. OTTINGER. Can you give us a clue as to what the problems are and what, if anything, we might be able to do to help resolve those?

Mr. SHARKEY. The basic problem is, in my opinion, and the problems are about the same whether we are talking about a renewable system or, say, a coal plant, it is a new way of doing business. I am sure you probably have seen a copy of the Defense acquisition regulations. They take up about—

Mr. OTTINGER. I helped write them, I hate to tell you. My job at the Air Force when I was there was to take volumes of regulations which were literally 5 feet high, and we made them 2 inches high, and I looked at them 2 years later and they had only gotten back to 2 feet high. [Laughter.]

We made some progress.

Mr. SHARKEY. You are aware, therefore, that you are dealing with a pretty cumbersome, inflexible system that takes a certain amount of time for people to understand what it is you are trying to do. Here we are, we are accepting some investor's money. This investor is going to make all kinds of bucks as a result of third party financing, and a lot of real concern on the part of our contracting officers is this legal, is it moral, is it right, does it fit anywhere in this framework that we understand? It is a very, very large education job. I think that is fundamentally what we are dealing with.

As I said, the Navy has made great, great strides. The Air Force is behind them. They are working, too, right now with the solar system at the Academy and a coal plant at Chanut Air Force Base. I think once they have digested having done that, the next one or two will be quicker and easier, and so on and so forth.

Mr. OTTINGER. Mr. Sklar brought up the problem which I think is a real one of relying on electric grids and the vulnerability of existing systems to potential for use of renewable systems as backup systems to prevent that. What is the status of your examination of that problem?

Mr. SHARKEY. This is a case where the Air Force is the lead service in this area. They have done a lot of good work. They have published the energy vulnerability assessment handbook which they have distributed to their bases and which we are going to get to other bases to show the local communities how they go about assessing the vulnerability of their installation to cutoffs and what not and to look at what the alternatives are. Clearly, renewable energy forms, where the location is appropriate—if you have a base with forests around it, wood makes a lot of sense, and so forth—where the opportunity exists, it just makes a lot of sense to do it.

Mr. OTTINGER. What is being done to see to it that it happens?

Mr. SHARKEY. Well, it gets to be a judgment on a case-by-case basis on how much you are able to invest in energy security at that particular base, depending upon—first of all, at some of our TAC and SAC bases, for example, we have in fact gone in and we have pulled the plug. We have disconnected the electricity to see if we could generate flights. We can generate flights because these are diesel generators and what not. We have lots of backup power.

Where we are getting more concerned is about our logistics bases, all of our warehouses are mechanized and computerized, what happens in those cases? We are pushing it. It is in the Defense guidance that the military departments are each year, as they build their program budget, to pay particular attention to that.

Mr. OTTINGER. We on this subcommittee apparently are getting some of the documentation to which you are referring. We kind of like to see it as it emerges. It affects renewable energy. Specifically, you referred to regulations with respect to third party financing and now new guidance with respect to vulnerability. We would appreciate it if you could furnish that for the record here today, and then think of us as you make further progress because I think it is helpful for us to be informed.

Mr. SHARKEY. Certainly.

THIRD-PARTY DEPPM

Answer. Material supplied for the record by Mr. Sharkey in response to Mr. Ottinger's request.



OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

MANPOWER,
INSTALLATIONS
AND LOGISTICS

23 MAY 1984

Defense Energy Program Policy Memorandum (DEPPM) 84-7

MEMORANDUM FOR DESIGNATED ENERGY OFFICIALS OF THE OFFICE OF THE SECRETARY OF DEFENSE, ORGANIZATION OF THE JOINT CHIEFS OF STAFF, MILITARY SERVICES, AND DEFENSE AGENCIES

SUBJECT: Third Party Funding of Facilities Energy Systems

PURPOSE: This memorandum advises the Military Services and Defense Agencies to pursue the use of third party funding of major facilities energy systems and sets forth parameters for this use.

BACKGROUND: The use of third party financing for the construction of major energy generation systems for Defense facilities has been seen as a potential alternative to military construction funding for many years. The Congress in Public Law 97-214, the "Military Construction Codification Act," granted authority for the military departments to enter into long-term (up to 30 years) contracts for the purchase of energy products from non-Federal facilities. In the FY 1984 Armed Services Committee report on the Military Construction Authorization, the Conferees stated that they did not believe that the Services were making full use of this long-term contracting authority. They specifically withheld authorization of two heating plant projects in the FY 1984 program until a reasonable effort was made to obtain a third party contract for provision of the needed service. They further stated that the military departments are expected to demonstrate to the Committees aggressive exploration and pursuit of third party financing before they will consider authorizing any energy plant project to be built with appropriated funds.

DISCUSSION: Contracting for the construction, operation and maintenance of a major energy plant located on a Defense installation can be a least life cycle cost alternative to Defense funding and operation of a similar plant. Current legislation allows Defense managers the ability to take advantage of commercial expertise, efficiency, and prudent risk in innovative energy systems. Careful evaluation of commercial alternatives must be made to insure that the basic mission of the installation is not compromised in any way and that the purchase of needed utility energy is at the lowest available life cycle cost when compared with a Defense financed plant and other commercial alternatives.

Each major energy plant is unique and the necessary evaluation of commercial capitalization will require significant technical, contractual, and administrative resources. General policy is necessary to insure consistency of review and fair competition between private proposers, and as a framework to prioritize this effort to achieve maximum benefits from available resources.

POLICY: The use of third party funding of major new energy plants shall be carefully investigated and evaluated prior to the request for military construction authorization for Defense-owned and operated plants to provide the same service. Investigation may include publicly soliciting indication of contractor interest. However, requests for military construction shall be made only if mission support reliability would be clearly degraded by a contractor-operated plant or the military construction-funded and Service-operated plant is clearly the least life cycle cost option, or there is no contractor response from a public solicitation. The attached guidance shall be used to evaluate third party funding applicability prior to requesting Congressional authorization.

RESPONSIBILITIES: The individual military departments and agencies are responsible for insuring that thorough evaluation of the option of third party financing is made for all appropriate facilities energy system projects. Within 60 days of the issuance of this DEPPM, DoD Components are requested to submit to me their formal implementation of this guidance.

Robert W. Daniel, Jr.

Robert W. Daniel, Jr.
Deputy Assistant Secretary of Defense
(Logistics and Materiel Management)

Enclosure

Third Party Funding Guidance

Project Applicability -

The military departments are authorized and encouraged to enter into contracts with third parties to construct, own, and operate energy systems on Defense property. All proposed new plants, or plant rehabilitations affecting 50 percent or more of the plant capacity, with a thermal energy input of 100 MBTU per hour or greater, within the continental United States, Alaska, and Hawaii, must be evaluated for third party funding prior to requesting Congressional authorization.

Projects meeting the following criteria may, but need not, be subjected to the use of third party financing:

- projects with a total plant thermal input of under 100 MBTU per hour,
- projects outside the continental United States, Alaska, and Hawaii,
- projects constructed solely to provide emergency or standby capacity, and
- modifications to less than 50 percent of the heating and power plant capacity where the extent of contractor ownership and output could not be readily segregated from that of the Government.

Military departments must be aware that the Congress' intent is that this alternative to military construction is to be vigorously pursued. Any individual project for power plants which has not been given comprehensive evaluations will come under scrutiny. Project sponsors should provide, with the authorization requests, clear explanation of the reason for not utilizing or formally considering alternative financing.

Economic Analysis -

Decisions on the desirability of third party financing for each specific major energy system is the responsibility of the individual military department based on a comprehensive analysis of all potential advantages and disadvantages. Least life cycle cost is one of the primary considerations. In order to allow equitable comparisons of possibly widely varying, competitive proposals with the preferred Defense-constructed plant design, life cycle cost analysis shall be made using the standard DoD constant dollar procedures directed by DODI 7041.3, and shall specifically incorporate the following constraints:

- present worth discounting will be done using a 10 percent discount factor;
- the latest official regional average energy cost escalation rates (industrial sector) provided by the Department of Energy (DOE) will be used for projecting

future energy costs and developing appropriate present worth values for future energy costs.

- Traditional experience-based construction and maintenance estimates shall be incorporated into the cost analysis.

The actual contractor cost proposal will be used for final project determination and negotiation. All basic economic assumptions should be clearly and separately identified for possible future renegotiation.

Federal Tax Considerations -

The Congress is encouraging investment in capital equipment and has enacted legislation that provides substantial tax incentives in support of capital purchases. On the other hand, Congress is currently reviewing the applicability of the tax incentives to contracts with non-profit entities such as the Federal Government. Currently, DoD considers these incentives may be applicable to its suppliers, but recognizes the responsibility to make informed decisions when considering third party funding which may result in tax credits which could materially impact on the total cost to the Government.

In support of this responsibility, the military departments shall require in their solicitations that bidders/proposers provide for evaluation a complete breakdown of estimated anticipated Federal tax credits and liabilities relating to the project, including pertinent factors such as useful lives of proposed equipment and expected depreciation schedules, for the duration of the contract period. Knowledge of the estimated tax implications allows their consideration in comparing competitive bids or proposals and as a factor in determining the ultimate suitability of the third party contract. It is recognized that guidance in this matter is not definitive and that each case will be unique and must be evaluated by the contracting agency on the basis of all specific merits.

The Deputy Under Secretary for Acquisition Management, testifying on Federal Leasing Practices before the House Ways and Means Committee, Subcommittee on Oversight, on February 28, 1983, stated that the Department of Defense considers the tax impact as a cost to the Government in all economic analyses of lease or rental versus buy decisions. While it is not clear that a third party contract would be considered a lease, it is clear that some consideration of the total cost to the Government as the result of such contracts should be addressed during the decision making process.

The Federal tax implications, as well as all other pertinent factors of proposed third party contracts for the provision and operation of energy production facilities, will be reviewed for approval by the Assistant Secretary of Defense (Manpower, Installations and Logistics) in conformance with the authority vested in the Secretary of Defense by section 2394 of Title 10, United States Code.

Energy Sources -

Section 2690 of Title 10, United States Code, states that except in "rare and unusual cases" new heating plants with an input heat rate of 50 MBTU per hour or more that use oil or natural gas may not be constructed on lands under the jurisdiction of the military departments. Obviously, any third party plant constructed on a Defense facility would be subject to this direction. The law allows the Secretaries of the military departments the discretion of waiving this fuel restriction by notifying the appropriate Committees in writing. The intent of Congress should be followed and prospective proposers should be informed of this constraint. This should be considered a rigid restriction. However, the military departments are encouraged to pursue the appropriate waiver and so notify Congress where economics overwhelmingly dictate the use of other fuels.

User Coordination -

The Department of Housing and Urban Development (HUD) has been studying the feasibility of third party financing of district heating systems to help revitalize economically depressed interurban areas. HUD has funded feasibility studies in many cities and has a program of matching block grants to assist municipalities in attracting private capital. In those urban areas near Defense facilities, HUD would like to have the facility energy requirement be considered as a possible "base load" of such district heating or cogeneration plants. It is the policy of the Department of Defense that cooperation with, and support of, such beneficial programs of other Federal and local agencies should be given within the bounds of the installation's legal authority and with primary consideration given to continued, reliable mission support.

Mr. OTTINGER. What is the level of DOD funding for R&D in renewable energy applications for DOD use?

Mr. SHARKEY. Looking at the activities going on in the laboratories that we have, I would say it is around \$5 million a year.

Mr. OTTINGER. Have you been able to pick up any of the near-term demonstration work that the Department of Energy has had to drop?

Mr. SHARKEY. We have not. There are probably a couple of reasons for that. Probably the keenest is we have had from the Armed Services Committee over the years concern that we spend military R&D dollars doing things that other agencies should be doing, and especially energy R&D. A few years ago, I can't recall which fiscal year, but the Armed Services Committee zeroed out the Navy's energy R&D budget, and that kind of got our attention at the time.

I think they understand now that there is a level of energy R&D we must do in order to learn how to adapt technologies to our use, even though they look like a civilian technology. We have since then been—

Mr. OTTINGER. I have never understood. I have talked to Stratton and Sonny Montgomery and said energy has to be one of your real concerns. You can get a cutoff in the Middle East again and you can't run the military and the civilian operation, particularly if there were some kind of a crisis in those circumstances. During any kind of military crisis, your civilian energy use skyrockets as

well as plants operate extra shifts, more people travel to work, and so forth. It does seem to me that there is a case to be made there.

One of the things I have always been concerned about is not in the context of this hearing but that the reserves that the military keeps are grossly inadequate. They are relying on the supply the same as the civilian sector is and it is much too slow for defense purposes, much too inadequate. It would seem to me they would be well advised to have military maintain larger reserves of product for its own use and take a look at alcohol fuels as a much more serious pursuit. They satisfy most military needs and do provide a good alternative and would help make a market nationally and internationally for those fuels.

Somehow or other the Armed Services Committee is not—maybe they view national security, it seems to me, in a very narrow context in terms of weapons. It seems to me that energy aspect of that is just critically important.

I don't know the extent to which you can be helpful there, but that is a matter which has long concerned me. I just can't get my friends on that committee to pay much attention.

Mr. SHARKEY. I understand what you are saying and, I think, reflect reasonably accurately the views on the committee as I understand them.

Mr. OTTINGER. Well, I hope you can do some effort to educate and we will do the same, but I think if the military were to make a presentation to the committee on energy vulnerability in the event of either a limited or a large emergency, that would be a pretty startling thing and perhaps produce some results.

I understand that you have some specific goals for renewable energy utilization by 1990 and 2000. Can you give us those?

Mr. SHARKEY. Yes. Basically, there are 5-year incremental goals. We start off with a 1-percent target for 1985 and 10 percent in 1990, 15 percent in 1995, and 20 percent in the year 2000.

These goals were made at a time when we never could have foreseen what has happened to the world oil market in the past 3 or 4 years and what has happened to the price. So, they are awfully ambitious looking at this point.

Mr. OTTINGER. It won't last.

Mr. SHARKEY. That is for sure.

One opportunity that we have to make a big dent in that is when the China Lake geothermal field comes onstream in 1985, hopefully. We will see some early measurable amount of energy.

Mr. OTTINGER. All right.

Mr. BARNES, can you tell us about the Academy's problems in working with Accurex to structure a third party agreement and why it has taken more than a year to complete the paperwork on the project or what could be done to expedite similar projects in the future?

Mr. BARNES. The contract for that project has been signed for about a year now, and we have been in the approval process. Previous language in the 1979 Military Construction Authorization Act permitted us to enter into 30-year fixed term contracts for utilities which made this third party type contract work for us. Our objective was to meet that 1985 renewable goal that Mr. Sharkey just spoke to.

What happened was we wrote the contract at our level, wrote our request for proposals, negotiated the contract, wrote that contract, and as we went through the learning process, we understood what we did very clearly. Then, when we put it before a whole new set of eyes and minds to review, there were questions that had not been previously asked that we had not asked ourselves.

Mr. OTTINGER. What kinds of questions?

Mr. BARNES. Land use was an issue. Essentially what we are doing is giving the contractor the right to come in and harvest our solar resource and to use an area of our land to do that. He is taking two resources, putting them together into a usable form, and then we buy the product of that which is high temperature hot water.

One of the issues that came up was the land use issue. Do we outgrant the land, do we give them the land, do we write a lease, do we ignore the issue? So, that took us some time to understand and decide what to do. There have been different opinions on how to do that.

Another difficulty that we had with it was that although this project shows a very good life-cycle cost savings to the Air Force, it has some negative cash flow in the early months of it. We negotiated a higher initial rate than we were currently paying for a very flat inflation rate which we think is appropriate for solar. Once you get a system in, your operating costs should be your O&M costs.

That negative cash flow in the early months of this project disturbed some of our people, because the stereotype perception of a third party agreement is that we as the user enter into it with no investment, if you will. So, in addition to the third party, we had a tricky rate structure that caused some internal discussion. I think that we have resolved those issues now.

Mr. OTTINGER. Are there barriers that you see that still need to be resolved in this third party area? Is there anything you need from Congress to help overcome them?

Mr. BARNES. I think we need all the help we can get from every place. It is a whole new exercise.

Mr. OTTINGER. That isn't very helpful; I need specifics.

Mr. BARNES. To be more specific, as I examine how we go about doing this thing, I find that there are three or four ingredients that we need to write a request for proposals for procurement in our system. One, we have to understand the procurement regulations which are like this. [Indicating.]

Then, we need to understand the commodity we are buying from a technical point of view. Finally, we need to understand the incentives that play in this contractual arrangement that we are entering into.

We don't have much difficulty with that. We do it rather well.

When we get into a third party type arrangement, another element enters into the equation, and that has to do with the tax incentives and how they apply. Tax law is not an area that we are expert in, because it simply doesn't apply to most of what we do. So, we have a very low level of knowledge in that area. That absence of knowledge becomes a barrier to us.

Therefore, we have started down the track of educating ourselves. However, beyond that, I don't see any particular barriers to the third party type agreement.

Mr. OTTINGER. Mr. Sharkey, how would you view a mandate that would apply across the board, not just to the Department of Defense, that you have to buy renewables if they prove to be least cost on a life cycle basis?

Mr. SHARKEY. I don't know if I should stick my foot in that one, but clearly, since we have the mandate now, it will not affect the Department of Defense.

Mr. OTTINGER. Have you not had any problems with implementing that?

Mr. SHARKEY. No, we have not. In fact, in some ways, from just an energy advocate point of view, we have found it useful. It keeps our eye on the ball, if you will.

Mr. OTTINGER. All right.

Mr. Phillips, the conference that I attended in Nairobi, the first U.N. New and Renewable Energy Conference, our industry got a rude awakening, really felt that the incentives that were being given by the other governments were so great that even though our technology was superior, our ability to make sales abroad was being impaired, primarily on the basis of the financial incentives that were being given, but also on a much more aggressive government assistance in terms of demonstration projects and things like that that were being performed abroad and kind of lost leader promotions where the government would make these demonstrations and turn over equipment at no cost or very little cost so that the Third World countries had an opportunity to gain some experience and then, of course, would buy their products.

What can we do or what is being contemplated to do to compete in that kind of an atmosphere.

Mr. PHILLIPS. Well, addressing specifically the demonstration programs, the Department of Commerce has not been and does not get involved in demonstration programs.

Mr. OTTINGER. What on earth kind of an answer is that? Is there a reason for it?

Mr. PHILLIPS. Well, it is not our mandate, really. We haven't regarded it as a strong marketing tool for developed products, which is what the Commerce Department really is. We, the Department of Energy, and other branches of Government have had demonstration programs, so we don't have the personal experience of having conducted them.

We also, and taking a look at it from the standpoint of marketing devices, are not convinced, in some areas and maybe even in renewable energy, that they have been that advantageous considering the investment required, even to other countries. We propose to look at that in our competitive assessment to see whether or not it has meant a good return on the investment made.

So, I can't respond directly to the value of demonstration projects, nor do we anticipate the Commerce Department proposing any.

We believe, particularly in the photovoltaics, that we are at a point now where a real, live application that has met all the requirements of economics and the commitment of the user to see to

it that it is applied correctly and used correctly is what we really need. Therefore, it is a trade promotion effort, at this point, I think we need.

In the trade promotion area, I mentioned the financing. We face that problem for all exporters of the United States in terms of matching financing arrangements that are supported by other governments. The interesting aspect, particularly in energy, is that the customers are generally either governments, government controlled, or government sponsored organizations. In the same way, our competitors overseas are frequently government supported and partly owned by foreign governments.

Those efforts by our foreign competitors in providing or matching financing incentives are generally for other reasons than marketing. They are to protect an industry, to protect employment, for a lot of other reasons that the Department of Commerce is not responsible for.

We think that there are ways to combat that kind of problem. In photovoltaics, for instance, the industry has not asked for special financing. I think they have asked for support that we believe we can give them, the Exim Bank can give them. It was mentioned earlier, to my knowledge, Exim Bank has had three requests for loans in renewable energy. Two have been turned down. One, I think, was for technological reasons. The other was because the country in question had such poor credit, it was difficult for good banking practices, to lend the money.

I think that the industry and Commerce, together with Exim Bank can take a look at a more aggressive approach to helping this industry and in renewable energy programs around the world.

Mr. OTTINGER. I am going to have to go vote again. Can you stay for a little while longer?

The Defense Department is excused. I have done all the questioning of you, and I thank you for your help.

However, I do have a few more questions, and, unfortunately, this vote came earlier than I anticipated, so I will have to go.

We will recess while I go vote.

[Short recess taken.]

Mr. OTTINGER. I thank you for staying.

Mr. Secretary, our testimony we have been getting about the Eximbank that we were talking about when I had to leave has all been very negative, and the testimony here the same with respect to its interest in financing photovoltaic projects and its feeling that it is worth its time to do small projects. Is there anything you can do to influence that?

Mr. PHILLIPS. Yes, sir. I believe there is quite a bit we can do and have been doing. The Assistant Secretary for Trade Development sits on the board of the Bank, and also on the board of OPIC. My staff works with the staff of eximbank on specific projects. I attend the board meetings and review the agenda ahead of time. We advise our Assistant Secretary on the vote.

We also frequently arrange for our Secretary to meet with the chairman of the Bank.

It has been an ongoing effort now for about 2 years. We really feel encouraged that the Bank—I wouldn't call it a change in direction, but a recognition of many things. For instance, the mandate

that it has now to meet mixed credit problems is a sign in the right direction. The emphasis on engineering services, on feasibility studies, change of emphasis I should say, and the emphasis on small business is beginning to change. I think it will take some time, but I think with pressure from Commerce or working with Commerce, I should say, and also with the industry. That is why I was encouraging industry to come to us, and we together will go to the Bank on some of these projects.

Mr. OTTINGER. That is very helpful, I think.

Is there any way to package some of these small projects so that it would be more in line with the size of projects that they are used to dealing with? If you put together four or five projects in different countries, maybe, that one company was——

Mr. PHILLIPS. Well, it is a possibility. As a banking institution, the credit worthiness of the borrower is important to them. It would be possible to put together some energy project in a specific country that totaled some amount of money that they would be interested in.

I personally believe that if we have a viable interesting project that is small that you can get the Bank interested. There just haven't been that many people requesting it.

Mr. OTTINGER. Well, that indicates a problem that was referred to today, and that is that the Bank hasn't been very aggressive in letting people know of the availability of its resources.

Mr. PHILLIPS. That is correct.

Mr. OTTINGER. Can you do anything in that?

Mr. PHILLIPS. They are perfectly willing to conduct seminars, and we are trying to help do that more often, but I think the Commerce Department can do a much better job in telling the industry about it and then in influencing the Bank.

Mr. OTTINGER. Can you put out some kind of literature to the industry—it is a small industry—and let them know of the kinds of assistance that the Commerce Department and the Bank have available for them?

Mr. PHILLIPS. Yes.

Mr. OTTINGER. I think just a letter from the Secretary indicating that there is this interest in helping people apply through the Bank and the Bank has a new attitude would be very useful, if that can be done.

Mr. PHILLIPS. Yes, we can do that. It is a good idea.

Mr. OTTINGER. All right.

Now, you indicated that you weren't prepared to match all the things that some of these other countries are doing to promote their products. We have had a good deal of concern, many of us in Congress, that the Commerce Department hasn't been aggressive enough in going after Japan and some of the European countries for doing things which seem to be in violation of GAT in terms of giving subsidies to their exports. I know the Secretary himself has been somewhat articulate in this respect, but I am not sure his words have been matched by actions.

That is another way to tackle this. If we aren't in a position to give matching subsidies, maybe it would be a good idea to go after the people who are giving these subsidies and see if we can turn it off.

Mr. PHILLIPS. It certainly is one of the things that we must do in coordination with the U.S. Trade Representative. Our Office of Trade Development is not intimately involved in those resolutions, just in reporting the problems that they cause us. I believe the Department of Commerce should approach those things aggressively, and hopefully, they will.

Mr. OTTINGER. I would think that an effort to collect the information on what, in fact, the Japanese and the Europeans are doing by way of subsidy and just turning those over to Mr. Brock and asking him to raise the issues with the countries with which he deals would be useful there.

Mr. PHILLIPS. Well, the distribution of that information is pretty widespread within Commerce. I know, although I am not personally involved, I read the reports that say what has happened in specific instances on specific projects. So, I am pretty sure that information is in there—

Mr. OTTINGER. Is that collected specifically for photovoltaics, do you know, or—

Mr. PHILLIPS. No, it is not, mainly because there hasn't been that much activity. Now that we have started and made assignments to take a good hard look at the industry, it will be done.

Mr. OTTINGER. I think it is going to be a huge market in the future. The price is coming down so rapidly, and since virtually the entire third world is in the Sun belt, the potential for its use is so great that the promotional effort would be well worth it.

Mr. PHILLIPS. Yes, we agree with that.

Mr. OTTINGER. There are many foreign countries that assist their vendors with actually paying the expenses of promoting sales and doing business abroad. Do we do any of that for companies?

Mr. PHILLIPS. We have a cost-effective approach to trade promotion which generally means that they pay. However, these industries in photovoltaics are generally small. Even if they are a part of a larger company, their division is small, and we have helped in sponsoring trade promotion activities where we pay half of the money and they pay the rest.

The interagency working group is going to take another strong look at that to see whether there isn't some more we can do to help.

Mr. OTTINGER. If you can give us some idea of the magnitude of effort that is being put into that and other promotional efforts in photovoltaics, it would be good for us as a benchmark so we can see how much or to what degree your plans are actually realized. Can you give us those figures for the record? I don't expect you to have them at your fingertips.

Mr. PHILLIPS. Well, as a part of the Wyden Act, we will be collecting that information to make it available to your committee or any other committee.

Mr. OTTINGER. We also would like to have from you, as I requested from the Department of Defense, on a current basis when you do a promotion or do a trade fair that involves photovoltaics, just to have that for our own records so we can get some idea of what is being done. We can pass it on to other people.

Mr. PHILLIPS. Yes, sir. I might recommend that we make arrangements for you to see the video tape that we have sent over to other countries.

Mr. OTTINGER. That would be very useful. We will do that.

Do you have any problems with the AID program and how it is conducted in this area, the coordination or lack of coordination with your efforts?

Mr. PHILLIPS. The only problem that I think we described applies not only to the renewable energy, but any other program, the mandate of the AID program in assisting the country that is involved without tying those investments to commerce. Whether that is right or wrong, the problem is that other countries really tie their aid for commercial reasons, every country that we know of. So, that represents one of those handicaps that we have.

Mr. OTTINGER. That is interesting. We don't require the funds that we give to those countries be spent for American goods?

Mr. PHILLIPS. Not necessarily. It depends on the project and what they are trying to accomplish.

Mr. OTTINGER. All right.

We thank you very much for your time and your interest. We will let you know—I won't be here, but the chairman I know who now chairs this subcommittee which I once chaired and the other members of the committee are really interested in this area and do look at it as a tremendous opportunity for the United States. So, we will be following your efforts with great interest.

Mr. PHILLIPS. We will see to it that the committee gets reports on everything that we are doing.

Mr. OTTINGER. Very good. Thank you, sir.

The hearing is adjourned.

[Whereupon, at 5:02 p.m., the subcommittee recessed, to reconvene subject to the call of the Chair.]

